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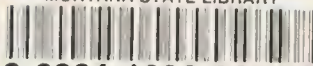
PROPOSED MONTANA RENEWABLE ENERGY PROGRAM

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PROPOSED MONTANA RENEWABLE ENERGY PROGRAM

from

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## INTRODUCTION: MONTANA RENEWABLE ENERGY PROGRAM

Montana, through state government leadership and state policy, leads the United States in its commitment to financial support of alternate renewable energy resource development and utilization. Public support of this program is widespread and based upon a sophisticated understanding of the logical match between the values and lifestyles of Montana with the positive social, economic, and environmental impacts of extended development of those renewable energy resources of sun, wind, water, and plant residues that already contribute so much to Montana's agriculture and lifestyle. It is recognized that the on-going national energy problem offers a great opportunity to integrate new energy production systems into the economy of Montana in such a way that they will enhance job opportunities for labor, expand economic opportunity for old and new businesses, and enrich the people by providing new technical, scientific, and business challenges. The colleges, universities, technical organizations, and businesses, as well as the emerging generation of young men and women will participate in and benefit from this program. The Montana Renewable Energy Program represents an unique way to simultaneously develop and enrich the state without compromising the quality of life or degrade the environment.

The Montana Department of Natural Resources and Conservation (DNRC) has had a very active program since 1975 which has supported numerous research, development, and demonstration projects throughout the state. To date, the key accomplishments of this program have been the creation of a very healthy public awareness, understanding, and support of alternate



renewable energy, widespread demonstration of the potential of solar space heating throughout the state, and the initiation of limited research and development activities in other renewable resource areas.

Montana has made a significant contribution to the overall United States energy R&D activities through the DNRC program. In turn, the state program has received considerable benefit from the national programs; however, the national program by its very nature will not satisfy all of Montana's needs. There are unique economic and environmental problems in Montana which must be addressed before full use can be made of national program information and results. Furthermore, the national energy R&D effort has received the benefits of Montana's developments that with various degrees of adoption can be used in other states and regions. Much of the past state program support has had this as one of its objectives. Now, however, is the time for a significant expansion, integration, and extension of the program. A properly structured, funded, and managed plan of research, development, demonstration, and commercialization is necessary in order for the state to fully benefit from the renewable resources available.

The Montana Alternative Renewable Energy R&D program must be more fully and formally integrated into the national U.S. Department of Energy programs. It must also be extended to include a strong commercialization effort and be expanded in terms of resources devoted to the total program activities.

This document contains seven specific subprograms for wind, biomass (agriculture and forest products and residues used for direct combustion, the production of alcohol, and the generation of methane), geothermal, solar,



and small scale hydroelectric renewable energy sources. The proposed duration of each of these subprograms is six years if the funding level requested is provided. At the end of this time, the technologies and supporting Montana business structure will have been developed for those renewable energies which have proven to be economically viable. State support beyond the six years will be minimal and will be limited mainly to coordination and information exchange. No large scale funding of development or demonstration projects should be necessary.

The support for this program is based upon a match of almost five federal dollars for every state dollar contributed. This match is not arbitrary but is based upon the concept that there is at least five times as many opportunities to use the results of this program outside Montana as within the state. Simple equity dictates that the division of funds for support be based upon the probable benefits to be obtained by each of the parties participating in the program.

The long range objective of this proposed Renewable Energy Program is to ensure the proper place of these resources in Montana's future economy. Diversification of energy sources will be just as important in the future as it is now. The utilities and their electric distribution system will become more valuable. Eventually, replacements for natural gas and liquid fuels must be found either by a complete energy form replacement or from gases and liquid fuels derived from biomass or from coal for some finite time period. Here again, the large energy companies and their distribution systems will continue to play a leading role. A new and important member of the energy team, the farmer/rancher and communities, is developed by this program.



Montana is an agricultural state with very little in-state processing of the products of beef and grain. Furthermore, our ranchers and farmers pay high transportation costs to get these products to the processing points and markets. The proposed program will provide some energy self-sufficiency and a significant extension of the agricultural activity into the processing area. The economic diversity of the farm, ranch, and forest communities will be expanded by energy "crop" growth and processing. The program provides Montana the opportunity to produce new, needed energy products and to participate in the processing of the products--a double economic impact.

The proposed subprograms are to be integrated into the Montana Department of Natural Resources and Conservation, Energy Division's "Montana Alternative Renewable Energy Sources Program Plan" published in January 1979. This present DNRC plan is for a two year program using funds from the coal severance tax as provided under the present allocation scheme. The DNRC plan projects funding of approximately \$800 and \$1,100 thousand for the next two years and will require additional funding in future years, before all objectives are met. What is proposed here is a significant expansion in effort of the DNRC plan while maintaining its program philosophy, management, and control. This expanded effort will answer the question of the usefulness to Montana of its renewable energies and, at the same time, will develop the necessary Montana businesses so that future state energy planning can be based upon technical and economic experience in renewable energy sources.



A primary motivation for the continuation and significant expansion of the present DNRC program is based upon the projected economic return to the people of Montana. The great majority of the important renewable energy resources are owned or controlled by individual land owners in Montana, e.g., biomass, solar, wind, and geothermal. A statewide program using these resources will, in addition to directly benefiting the resource owner, create the supporting businesses and manufacturing activity. Thus, one objective of the Renewable Energy Program is increased economic activity within the state at the individual and small-to-intermediate business level. This program is not dependent upon large corporations moving into the state, but rather, the creation within Montana of new businesses. By the year 1985, this expanded program has the potential of generating business activity in the millions of dollars which will directly benefit the citizens of Montana.

Agricultural/forest products and residues (biomass), geothermal, and wind are the three renewable resources with major subprograms that will be fully developed and commercialized under this plan. Farm and forest residues will be used for production of alcohol and methane and for direct combustion to produce heat and possibly electricity. Wind will be used for electricity generation. Geothermal resources will be used for space and industrial/agricultural heat. Full commercialization means to perfect the applicable technologies for Montana, establish the economics of utilization, create the supporting industrial base, and finally manufacture/build and install the system/facilities throughout the state. Montana capital and Montana citizens can do this via indigenous internal growth and with only a relatively minimum initial funding from the state and national government.



One element of the biomass portion of this program is directed to community- or county-size alcohol plants of a nominal  $10^6$  gallons/year output which would be fully integrated into the local community. A plant of this size can be built, owned, and operated by the community or individuals with minimal outside assistance. The initial market for the alcohol and the by-products would be the community and surrounding region. Support for five plants is proposed.

The second major element of the biomass program is the direct combustion of forest or farm residues in community-size heating plants and for individual residential-size heating units. Many regions within the state have residues which because of climate, soil, or harvesting practices must be disposed of frequently at some expense to the land owner. These residues can be converted into an additional cash crop. Support for four plants is proposed.

During the six years of the program, alcohol plants and direct combustion plants will be partially funded, and testing and evaluation of home-size furnaces and stoves will be continued. The degree of state financial support will be limited to design and 90 percent or less of the construction costs of the facilities. At the end, the technology and operating costs will be established to such a degree that the succeeding plants established in the state can be fully financed by private funds.

The last element of the biomass program is biogas generation. Three sizes of biogas (approximately 65 percent methane) facilities will be developed under the biogas subprogram. One community waste, supplemented with agriculture or forest residues, biogas generator facility will be designed and constructed. Two dairy farm or feed lot size facilities will be installed, and finally a smaller farm or ranch size model will be developed. Three design iterations are provided for in the small size and a total of nineteen units will be purchased for ranch and farm testing and evaluation.



The integration of a community-size biomass program will also include appropriate supporting agricultural activities. For example: alcohol production creates high protein feed which can be used to feed cattle, and the manure from the cattle can be used to generate methane which in turn can be the heat source for the alcohol production.

The wind element has two major portions--first, the individual land owner wind generation concept and secondly, the large utility-owned wind farm concept. The land owners in Montana possess an enormous wind energy potential which, with the development of properly scaled and designed wind electric or direct mechanical generators, can be "harvested" for farm and ranch use. In addition, it can be fed back into the electric grid system. The farmers would be paid for any excess electricity they generated by the utility company; hence, the land would provide a second cash crop. Support for 60 farm-size (20 KW) wind generators is proposed. In addition to the siting of individual wind generators, Montana possesses numerous prime sites, some in conjunction with hydroelectric generation facilities that could be used for large wind farms with a generation capacity of as high as a few hundred megawatts. The Bureau of Reclamation, Corps of Engineers, and the utility companies will be encouraged to establish wind farms with a generating capacity of 250 MW by 1986, an amount equal to that to be generated on farms and ranches. Besides this electric generating capacity, this commercialization plan will create the manufacturing, erection, and maintenance industries in the state to support this renewable energy re-use.

The geothermal hot water resources of the state will be evaluated for community and industry-size facilities for space heating and industry/agricultural applications. A prime site in the state will be developed to provide a central community heating system. If an appropriate user can be identified,



a program will be developed that will demonstrate the use of geothermal heat in industry or agriculture. Support for two geothermal sites is proposed.

The solar and small scale hydroelectric subprograms are funded at less than one million dollars each for the four year period. These subprograms require less state support because of state-of-the-technology due to past state and federal funding. Three tasks remain to be completed in the solar subprogram. These are: the evaluation of the solar demonstrations that have been funded, assistance in providing commercially available low cost solar panels for homes, and assistance in the design of solar heating systems for commercial buildings, apartments, or communities. The small scale hydroelectric subprogram will provide for the design and cost analysis of up to twenty hydroelectric generation sites in the state and funding to support up to 90 percent of the construction for ten sites. The electricity output from these sites will be limited to no more than 20 KW.

It is recommended that the Energy Division of DNRC continue the management of this expanded renewable energy program with assistance from major subcontractors for each of the renewable energy resources. By properly structuring the contractual responsibility and work, this program can be managed without an increase in the permanent staff of DNRC. One program objective is to establish within the state the technology and management capability for renewable energy sources. This is to be done by building up Montana private industry and business and not by an expansion in the number of state employees. The major portion of the work will be performed competitively in response to "Requests for Proposals" (RFP) and only a limited amount will be by unsolicited proposals. During the first three years, three or four temporary staff personnel will be needed in the Energy Division to



start the program, establish office operating procedures and policies for the expanded effort, and provide the necessary close subcontractor direction required during the initial phases of the subprograms.

The key to program control in this plan is the annual in-depth total program review by subprogram element performed by a review team composed of legislators, DNRC subcontractors, and nationally renown experts. All activities will be reviewed, and any necessary budget adjustments will be proposed to the Montana state legislature and the U.S. Department of Energy for the coming year. It is vital that the program remain dynamic and that adjustments in expenditures be allowed and encouraged in a public policy directed manner so that advantage can be taken of unexpected program accomplishments or opportunities. In the same respect, expenditures should be cut or terminated in any subprogram that does not meet the projected economic pay off for the state.

The total funding recommended for these programs is \$46,800 thousand. This is the amount obtained by adding all the subprogram totals in this plan plus an additional \$5,225 K for DNRC management during the six years of the program. Montana's share is \$8,600 K and is based upon projected return from the coal tax revenue. It is recognized that the state legislature can only make a two year commitment, and that is all that is necessary from the state and the U.S. Department of Energy to start the program. If successful, the remaining funds would be requested from the 1981 and 1983 legislature and the U.S. DOE. For full funding of the first two years, the state must provide \$900 K in 1979 and 1,100 K in 1980 and the federal government \$2,700 K and \$4,400 K in each of the two years. The funding level requested is significant, but the program is structured so that each succeeding year's budget is spent only if the prior year's activities were successful.



The program will be coordinated with the Department of Agriculture and Small Business Administration Energy Loan programs. The USDA Business and Industrial loan program can become a vital part of this program in supporting the development of the required industrial base in Montana. In addition, the products developed must be "approved" by the USDA so that the farmers and ranchers can obtain FHA loans in support of purchase. Public Law 95-315 changes the Small Business Act to provide funds for energy related activities and facilities.

This document details a flexible, diverse but integrated expanded alternative renewable energy program that simultaneously addresses major national needs as well as the unique requirements of Montana. This program is designed to serve the broad public policy needs of Montana through stimulation of development in the private sector. Furthermore, this program recognizes and addresses the needs for new community scale technology that will allow the communities to have at their command technology that will not be imposed from outside the state by organizations that have optimized the production for their benefit. Moreover, these technologies and energy sources will reverse the long term trend of Montana's economy of being based upon exporting unprocessed agricultural and natural resources. Unlike coal, where processing involves significant environmental impacts with existing technology, the development of alternate renewable energy resources can be developed with minimal negative impacts.



## COMMUNITY SIZE ALCOHOL PRODUCTION SUBPROGRAM

### Introduction

As our petroleum supplies decrease, energy will become a larger portion of living costs if we maintain our current life patterns. The farmer is aware of this since he depends on gasoline, fuel oil, and electricity. The costs of these resources have been escalating much more rapidly than farm products. Today, the farmer is an importer of energy. The future could be different--as these "conventional" resources decrease, other energy sources will become cost competitive.

The Great Plains of the United States is the largest and most productive area of renewable energy sources in the world. This region represents by far the most significant asset of our country; and in the future, in addition to food, it will become an energy producer.

It has been estimated that 75 quads of electricity could be generated from wind in the United States without affecting the present weather patterns.<sup>1</sup> This is equivalent to the present yearly total energy consumption in the U.S. The wind energy subprogram section describes in detail how Montana's farmers and land owners will benefit from this resource. Wind is only one new farm crop; the other two important new Montana farm or forest energy crops are liquid fuel and biomass residues for direct combustion. This section will present a program for liquid fuels.

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<sup>1</sup> "Wind Energy Resource Parameters," M. R. Gustavson, Proceedings, National Conference, American Wind Energy Association, March 1978.



With the present technology base, the most appropriate liquid fuel from farm and forest products is alcohol. Certain European and South American countries have had extensive active alcohol production facilities for 30 to 40 years which use farm and forest products. Experience has shown that anything up to 20 percent alcohol has no effect on a vehicle's engine performance,<sup>2</sup> and with engine adjustment, 100 percent alcohol can be used. Sometime in the near future, depending upon OPEC pricing policy, gasoline could reach a price where large scale production of alcohol from farm products will become a reality. No new technology is required; however, improved total system plant operation and by-product utilization will hasten the date that alcohol becomes competitive. In addition, it is possible that new farm crops may be developed that will yield a higher alcohol return per acre.<sup>3</sup>

There is the possibility that new environmental laws covering gasoline additives could greatly benefit the use of alcohol in gasoline. The price paid by petroleum companies for gasoline is a closely guarded secret; therefore, the real value that alcohol might have is difficult to determine. Tests have shown that for 80 percent octane base stock gasoline, each one percent of alcohol improves the octane by about one percent. For higher octane base stocks, the improvement is less.<sup>4</sup> Alcohol also might have other qualities, such as suppressing pre-ignition. Any government requirement to use other additives, or alcohol specifically, in gasoline would have a great impact on alcohol consumption.

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<sup>2</sup> Public presentations at Annual National Gasohol Commission Meeting, Chicago, Illinois, November 1978.

<sup>3</sup> "Alcoholic Fermentation of Jerusalem Artichokes," L.A. Underkofler, et. al, Industrial and Engineering Chemistry, Vol. 29, No. 10.

<sup>4</sup> Private communications, Cenex and Conoco refinery personnel, December 1978.



Of course, the interest of the Montana rancher or farmer is to raise the sale price of his current products, i.e., \$4.00 or \$5.00 per bushel for wheat rather than the current price. In some areas of the U.S., this may not be a simple economic problem because if the price is increased, more marginal regions can be converted or returned to farming resulting in larger production and a lower price paid per bushel.

The real farm objective is to increase the cash return per acre while maintaining or decreasing farm expenses of time and money. The average cash return on wheat acres during the past couple of years has fallen from a high of \$111.00 to a low of about \$75.00 per acre per year.<sup>5</sup> The return might be increased in the future by introducing a new second major crop that would be grown on some of the present grain acres and would be used to produce alcohol. This new crop would reduce the wheat output and, hence, raise the price paid for wheat; as a result, the wheat acres would produce a higher price per acre. Under the present petroleum costs, what must be the characteristics of this new crop? Assume the alcohol could be sold in large amounts at 80¢ per gallon, this amounts to 40¢ per gallon with current federal tax credit, and produce a profit for the distiller. In order to obtain \$120.00 per acre, the farmer would need a new crop that would produce about 240 gallons of alcohol per acre compared to the typical current wheat production of about 65 gallons per acre. These numbers assume an inexpensive community-size batch plant and sale of the protein by-product as feed at 30¢ per gallon of alcohol produced.

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<sup>5</sup> Montana Agricultural Statistics, Vol. XVI, Montana Department of Agriculture and U.S.D.A.



The weakness in the previous case is that there is no established or fully characterized farm crop that can be raised in Montana, with the same or less farm inputs, that will produce four times the alcohol output as wheat. An extensive effort by agricultural researchers has not been made to develop such a crop. This problem certainly merits considerable attention. Hopefully, as the price of gasoline increases, the development of a new crop and supporting farming practices with increased alcohol yield per acre will be successful; and a portion of the Montana acreage can be converted to this alcohol crop.

The immediate objective of the proposed alcohol subprogram is to establish alcohol plants in Montana which use Montana-grown feedstock and produce at least the same economic return to the farmer as the current return from food production. There is a probability that a near term increased return is possible; however, this is dependent upon economic factors and markets outside of Montana which are very difficult to predict and control. With the present price of gasoline in the U.S., the best that can be expected is an equal return; however, as gasoline prices increase, an increase in farm revenues will be received. This program will develop the facilities, management, and technology in Montana communities so that Montana farmers and businessmen will be able to select their own role in the future liquid fuels industry in the U.S. The farmers and their communities are knowledgeable of and competitive in the role of food production. This program will extend that competitive advantage to alcohol production.



The long term objective is to significantly raise the dollar return per acre through the best combination of energy and food production on the farm. This will be possible with the local know-how established under this program.

The two key elements in the economics of alcohol production are marketing of the protein remaining from the feedstock and minimizing the energy required to produce each gallon of alcohol. Significant advances have been made in reducing the energy requirement from 200,000 Btu to 40,000 Btu and less per gallon.<sup>6</sup> Even at this lower level, the question remains as to whether or not the total process from crop planting to alcohol production is energy positive. The protein market is a problem that can be solved on two levels. First, protein can be sold on a local basis for cattle feed; in which case, this will probably limit the amount of alcohol that can be economically produced and consumed within each community. The second possible solution is to establish a national or international market for human consumption of the protein; in which case, a much larger quantity of alcohol could be produced. The identification of this possible large market will be pursued continually throughout the program.

The above discussion has centered on crops raised for alcohol production. Forest waste products have been used in Oregon to produce alcohol, and much research is being conducted in converting farm wastes (e.g., straw) to alcohol. If this becomes technically and energy efficient, the possibilities for greater economic return per acre are significantly increased. In addition, by using biomass wastes and a low energy intensive process, a net positive energy return is assured.

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<sup>6</sup> Public presentations at Annual National Gasohol Commission Meeting, Chicago, Illinois, November 1978.



## Community Size Plants

In the past few years, much has been written about alcohol produced for fuel from agricultural products or wastes.<sup>7,8</sup> The almost universal conclusion of these reports has been that alcohol cannot be produced at today's price for grain and be competitive with gasoline. In reaching this conclusion, certain basic assumptions were made about the price of grain, plant size, and market; and given these assumptions, the conclusion drawn seems to be correct. The plant and operational concept for alcohol production in this renewable energy subprogram is different from that proposed by any previous alcohol study, and under certain conditions can produce alcohol that is competitive with gasoline in Montana. There appears to be a very high probability that the range of conditions under which alcohol production is economical can be expanded significantly once operational experience is gained from an alcohol production plant which is integrated within a local farming community.

The concept of this program is to locate the first plants in communities that have the most favorable economic position. As experience is gained and construction and operational costs are lowered, communities with a smaller economic edge can be included and successful plants constructed. The typical factors which enhance the economics of a plant for a community are: use of existing facilities, high local gasoline costs, continued excess farm produce, high transportation costs for farm produce, local cattle feeding, and high cost for protein feed supplement.

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<sup>7</sup> Grain Alcohol in Motor Fuels, J. G. Kendrick and P. J. Murray, Report No. 81, Department of Agricultural Economics, University of Nebraska, April 1978.

<sup>8</sup> Feasibility of Ethanol from Grain in Montana, R. Stroup and T. Miller, Research Report No. 118, Montana State University, January 1978.



The first plants will be designed with flexibility in mind to operate using existing farm produce; in Montana, these are primarily grain products. Later, other crops producing a greater return of alcohol could be grown on a portion of the available acreage after research had verified the economics of such crops. The United States Department of Agriculture (USDA) will be encouraged to support this type of research during the program.

At the present time, Brazil has over 400 operational alcohol plants and is supporting the construction of additional plants. International construction companies are supporting the Brazilian program; in addition, some of the major construction firms in the U.S. have built, or are interested in building, alcohol plants. To date, the designs proposed by these companies for the U.S. have been the large capacity plants of 10 to 20 million gallons per year. Vulcan Inc. has proposed a two million gallon per year plant for \$12 million for the USDA loan program. There is one small company in the U.S., ACR Processing Corporation, who has joined with the Grain Processing Corporation to design smaller plants which use either a batch or continuous process approach. They have designed plants of a few hundred thousand to a few million gallons per year which require less than 40,000 Btu of energy per gallon of alcohol produced and which are operated by a small staff.

A recent ACR design was submitted for the \$15 million USDA loan program plant in southeastern Colorado. This design was for a continuous process plant with significant automation, and the projected total construction cost was a few million dollars; i.e., a couple of dollars per gallon per year.



The variation in plant costs can be seen when this is compared to the Vulcan design also submitted under the loan program for a group of potatoe farmers in eastern North Dakota.

Under an Old West Regional Commission contract, MERDI, in participation with a group from Glasgow and ACR, have performed a conceptual design for a batch plant which is more suitable to the Glasgow needs than these more expensive continuous process plants. The plant and the integration of alcohol production at the community level which is being proposed in Glasgow is the concept that is recommended for the first plants under this program. Tables I, II, and III provide some of the preliminary characteristics and costs for the Glasgow plant. During the next month these numbers will be further refined.

For the Glasgow plant, the grain supply will come from the plant owner's fields. There is indication that ranchers in the area will purchase the distillers grain as feed at the price indicated. The remaining question is what will be paid for the alcohol produced? Discussions have been held with the Montana Petroleum Association and distributors in Montana to determine the extent of interest. This, of course, is the key to selling alcohol. Studies<sup>9</sup> have shown that there is support for gasohol as a better product at a higher price than regular gasoline. There is also an indication of a projected increase in demand for premium unleaded gasoline. Adding 10 percent alcohol to unleaded regular gasoline will produce a product almost equivalent to unleaded premium. Given the economics of Table III, the 4¢ per gallon federal tax reduction, funding support for capital and operating expenses from this program of 21¢ per gallon, then unleaded regular/alcohol mixture

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Iowa Development Commission, "Consumer Acceptance and Market Potential of Gasohol," October 1978.



TABLE I

Preliminary  
Specifications for Glasgow  
Alcohol Plant

|                       |  |
|-----------------------|--|
| Type:                 | batch  |
| Capacity:             | 120 bushels per cook (960 bu/day)                          |
| Cycle:                | 3 hours per cook, 36 hours fermentation                    |
| Feedstock:            | Barley (2.0 gallons ethanol per bushel)                    |
| Fuel:                 | Coal (Montana; 10,000 Btu/lb)                              |
| Boiler:               | Low pressure (atmospheric pressure cooking)                |
| Beer still:           | 3 feet diameter  |
| Production rate:      | 1920 gallons and hydrous ethanol per 24 hour day.          |
| Grain storage:        | 30 days supply (30,000 bushels)                            |
| Product storage:      | 33 days operation (21,000 gal.)                            |
| Coal consumption:     | 6.25 lb/gal. (50,000 Btu/gal; 10,000 Btu/lb)<br>6 tons/day |
| Stillage production:  | 13,400 lbs/day (14 lb/bu)                                  |
| Fermenters:           | 12, 10' d x 12' overall height                             |
| Fermentation house:   | 32' x 96'  |
| Boiler house:         | 24' x 32'  |
| Distillation house:   | 30' d x 72' height   |
| Boiler:               | 200# tri-fuel (coal, oil, or gas)                          |
| Coal storage:         | Undetermined   |
| Waste water disposal: | Undetermined   |



TABLE II

Preliminary Cost Estimate  
for Glasgow Alcohol Plant

|   |                |
|---|----------------|
| Grain Handling and Preparation                  | (Undetermined) |
| Cooking, Fermentation and Distillation          | \$247,500      |
| Boiler  | 90,000         |
| Fermentation and Boiler Buildings               | 45,000         |
| Distillation Column Enclosure                   | 30,000         |
| Grain Storage                                   | (Undetermined) |
| Coal Storage                                    | (Undetermined) |
| Product Storage                                 | 19,000         |
| Gasoline Storage                                | 7,000          |
| Erection and Piping (20% of equipment & boiler) | <u>67,500</u>  |
|   | (\$506,000)    |

TABLE III

Preliminary Cost of Production  
for Glasgow Alcohol Plant

|   |                |
|---|----------------|
|   | <u>\$/gal.</u> |
| Feedstock (Barley at \$160/bu.)                                     | 0.80           |
| Energy (Coal at \$38/ton plus 10% for electricity)                  | 0.13           |
| Labor (\$10/hr. 2 men each shift)                                   | 0.25           |
| Cost of Working Capital (See footnote 1)                            | 0.0735         |
| Management (All components, \$30,000/yr.)                           | 0.0435         |
| Interest and Debt retirement (See footnote 2)                       | <u>0.137</u>   |
| Total   | 1.434          |
| Sales of Distiller's Grains and Solubles<br>(7 lb/gal. @ 0.075/gal) | 0.525          |
| Net Cost per Gal.   | 0.91           |

No Allowance for Taxes or Profit.

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<sup>1</sup> Working capital, 6 months of feedstock, energy, labor, and management at 12% ( $.12 \times 50,800 = 0.073$ ).

<sup>2</sup> Capital investment of \$550,000; a mortization of 12% loan in 10 years.



would sell for 3¢ per gallon more than the regular. The proposed \$2 per barrel government rebate, or 5¢ per gallon subsidy, has not been included in these calculations.

The Glasgow plant would require about 30,000 Btu's per gallon of alcohol if the distiller's grain is not dried. The significantly reduced energy requirement is not the result of any new technology but rather a very complete coupling of all energy generated and needed. This same approach is possible in the larger plants designed by other engineering companies in the U.S. The problem is that there has not been a great need in the past to reduce energy consumption in the conventional alcohol plants designed by these companies. ACR has been working on reduced energy consumption for ten years, primarily in small plants, and has thus worked up the right combination of system tradeoffs.

In essence, there is the possibility of two general size plants for Montana. The larger 20 million gallon size plant, costing \$20 million, must have a strong national or international market secured for the alcohol and by-products before construction would be feasible. Five plants of this size would use about one-third of the annual Montana grain production; however, any success would certainly encourage the corn growers in the East to do the same; thereby, developing strong competition. This is not an impossible objective, but it is one where we do not have control over all of the critical elements. As mentioned, this avenue should be continually pursued; however, caution is necessary.



The smaller community size plants appear to be best in Montana, with the market in the surrounding area. Initially, this approach will not impact grain prices. A source of feedstock must be secured, possibly by the grain farmers owning the plant. Then, a market must be secured for the alcohol and distiller's grain. This market information is essential for finalizing the plant design and operation, and this is an iterative process that is dependent upon the condition in each community.

With the present price of gasoline and the use of wheat or barley as the feedstock to the plant, alcohol production will not be a big money maker. The proposed program will provide the feasibility study, plant design, market identification, partial construction cost, and initial start-up and operation to the selected communities who have expressed an interest in such a facility. In addition, the program develops in Montana farm communities the technical and managerial know-how to enter into large-scale liquid fuel production in the 1990's. Any new high-alcohol producing crop or new technology for processing biomass waste will advance the date when alcohol production contributes significantly to farm and forest income.

#### Technical Program

A technical and management alcohol plant team will be formed which includes personnel experienced in farm products and operation, alcohol production plant design and construction, marketing, and plant management and operations. This team will prepare briefing material on all aspects of the program to be presented to interested communities. The information and experience gained in the Valley County alcohol project will be valuable to this team.



The next step in the program is for interested communities with the appropriate farm or forest product to form a private or community government affiliated organization that is a single point of contact. This organization will contact the state and express an interest in an alcohol plant. The alcohol plant briefing team will come to the community and conduct educational type meetings to explain the state support, possible plant size, operational considerations, funding requirements, typical economic return, etc. Printed material will be made available. The community organization will then decide if it would like to be considered as a possible plant site under the state program.

Members of the alcohol plant team will return to the community and assist them in preparing a detailed proposal to the state for support. Information on feedstock, market potential, plant size and location, operational and management concept, expected dollar return, and desired financial assistance will be generated. The community organization is responsible for submitting the proposal to the state. The state will select at least five communities to be supported during the program. Depending upon the level of funding requested, additional plants could be supported.

Hopefully, at least one large size plant (20 million gallons) can be established during the program. The same initial assistance will be provided for a community desiring a large plant; however, design and construction must be provided by private financing.



For the selected small plant communities, the next assistance step is the detailed engineering design of the plant and firming up the feedstock supply and product marketing commitments from farmers, gasoline dealers, and cattle feeders. A construction bid will be obtained from the plant design and the responsible community organization will finalize their construction funding support request to the state. It is desired that some community funding or in-kind contribution of at least 10 percent be included in each plant.

Construction supervision assistance will be provided by the plant team, and training of key plant operations will begin as soon as practical. The team will provide assistance throughout the check-out and during the first year of plant operation.

The five or more plants will not be constructed all at once but will be staggered a few months so that experience can be gained from plant to plant. A period of 18 to 24 months will be required from the time the alcohol plant team begins working with a community until a small size plant is operational.

A specific in-state ongoing crop research program is important to identify better crops for alcohol production in Montana. This research should be done at Montana State University. Much work is being done on a national level for waste or residue alcohol production which would have a great impact on the economics; the results of this research will be closely watched. The sooner wheat or barley can be replaced by a less expensive and higher alcohol producing plant, the sooner the farmer will receive greater economic returns. Any agricultural research program is long term so it is important to begin working with the communities with the alcohol plants as soon as possible on a gradual and experimental basis.



The alcohol plant team will provide technical and management support to the communities for the full four years of the program. A n important function will be exchanging information among the Montana plants and in assessing and disseminating research efforts that will benefit these plants. The team also will be available to provide information to communities who might desire to construct their own plant without state assistance. At the conclusion of this four year program, the construction and operational costs of the plants and the supporting in-state technical knowledge will be available so that interested communities can develop alcohol plants using consultants and commercial financing at minimum risk.

#### Additional Issues

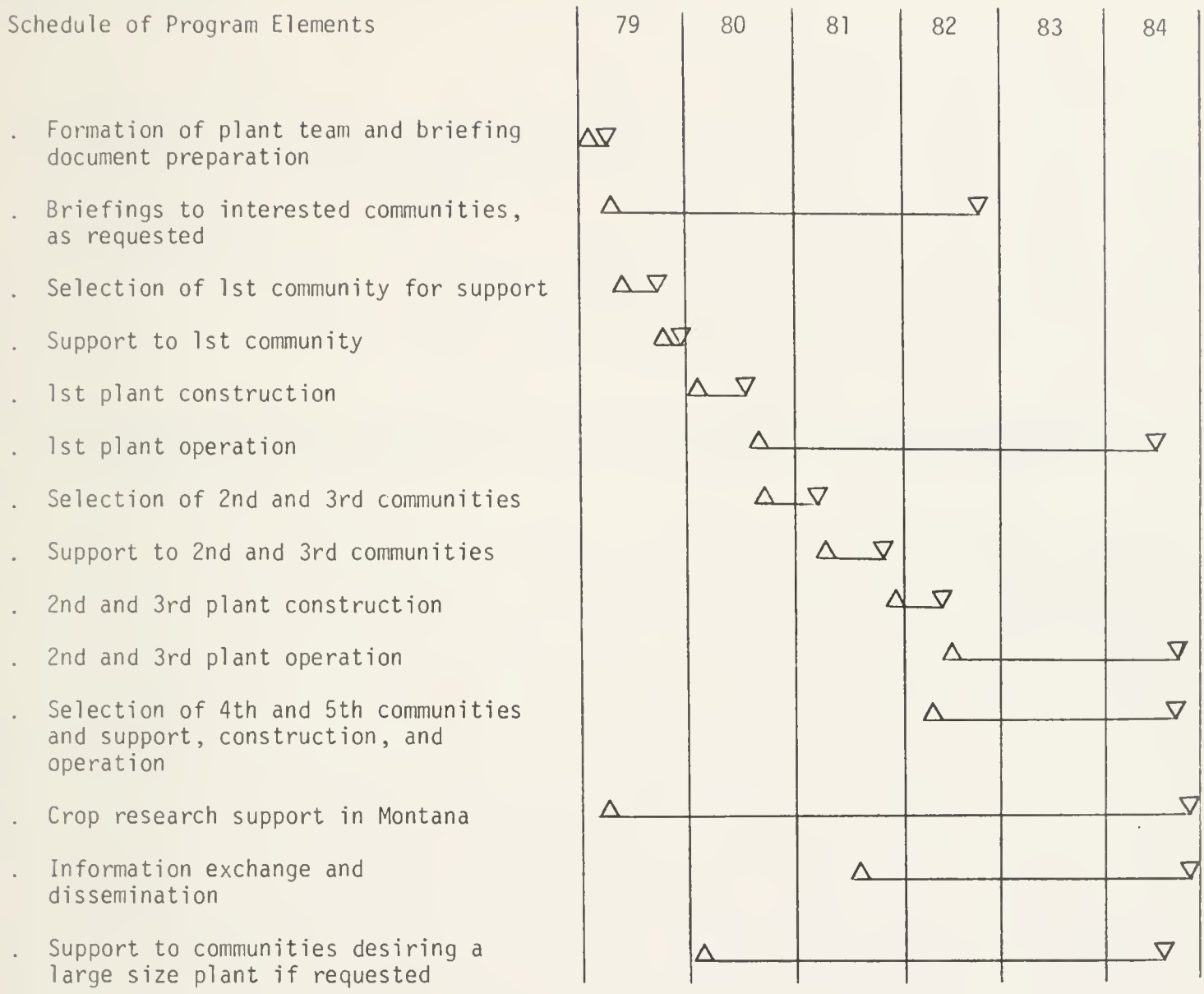
The price of gasoline or any EPA ruling on gasoline additives could have a very significant impact on alcohol economics. The probability is that the impact will be favorable. Other states have considered a reduction in the state gasoline sales tax during the first few years of a plant. This lost income would have to be made-up from some other source, and this sales tax reduction is not recommended for Montana. Another possibility is requiring that alcohol be added to all gasoline used in the state--this is a forced subsidy to alcohol production. Property tax relief could be considered for the first few years of a plant.

There is consideration of using a few cents "check off" on wheat to generate a fund which could provide financial assistance for construction. This concept would support this proposed program.



Schedule and Cost

Schedule of Program Elements





Major Cost Categories by Years (Dollars in Thousands)

|  | 79   | 80   | 81   | 82   | 83   | 84   |
|--|------|------|------|------|------|------|
| . Alcohol plant team                       | 700  | 700  | 550  | 400  | 300  | 200  |
| . Plant design and construction assistance | 300  | 550  | 200  | 600  | 1050 | 1150 |
| . Initial operation direct support         | 0    | 100  | 150  | 200  | 200  | 250  |
| . Instate crop research                    | 150  | 150  | 200  | 200  | 250  | 200  |
| Total cost                                 | 1150 | 1500 | 1100 | 1400 | 1800 | 1800 |

It is proposed that these yearly total costs will be shared by state and federal by a one to five ratio.



## DIRECT COMBUSTION OF BIOMASS SUBPROGRAM

### Introduction

Montana is a state with plentiful resources of biomass waste from farm and forest activities. These residuals have a Btu content per pound between Montana lignite and bituminous coals. One use of these resources is in the production of liquid fuels which is covered in another section. In this section, a program is proposed for the direct combustion of biomass for the production of heat and, possibly in some limited community-initiated uses, for the generation of electricity. For heat production, two sizes of combustion are to be supported; one is a community-size central heating plant distributing hot water in towns, and the other is for individual stoves or furnaces for homes or small businesses. This latter combustion program couples directly with the active and passive solar heat research and demonstrations that have been funded previously throughout the state. Community-size electrical generating plants will not be supported in the program. This would be a secondary benefit that might be considered by any community or rural cooperative once a central heating plant has been established. The electrical generating technology and cost trade offs between local generation with MPC and MDU back-up, and MPC and MDU full time power costs, can be determined without additional development or demonstration. Communities with central heating plants may or may not wish to consider this additional option which, if selected, would be at their own expense. This program does not contain funding in support of studies, development, or demonstration for electric generation.



The renewable biomass mass can be estimated from Montana's farm and forest production. Considering only wheat crops from the farm, and assuming that a pound of wheat produces a pound of straw, about 4 million tons of straw are produced from the 8 million plus acres under harvest in the state.<sup>1</sup> At present, the great majority of this straw is marketed or plowed back into the soil. Dependent upon the price that would be paid for straw used as a fuel, substitutes could be found, and some of this straw could be used as fuel. In one area south of Ft. Benton, about 100,000 tons of straw are available each year; therefore, an assumption is made in the calculations below that at some price, yet to be determined, one million tons would be available annually in Montana. The annual forest harvest in Montana had been about 200 million cubic feet per year.<sup>2</sup> Using representative data from the forest service on residues from sample forests in Idaho, Wyoming, and Montana, about one million tons of usable residue would be available on the ground after logging this amount of lumber. Thus, from farm and forest, two million tons of biomass are available each year in Montana. The present coal mining operations produces 30 to 40 million tons/year; thus, the renewable biomass resource is small compared to the coal resource. However, this annual statewide biomass supply is adequate to heat 50,000 homes from central heating plants and to provide ten tons of processed biomass fuel per year as heat for another 50,000 homes.<sup>3</sup> The point can be made that if the

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<sup>1</sup> Montana Agricultural Statistics, Vol. XVI, Montana Department of Agriculture and USDA.

<sup>2</sup> R. V. White and C. E. Keegan, "The Wood Products Industry in Montana," Montana Business Quarterly, Summer, 1978.

<sup>3</sup> Individual homes  $10 \times 50,000 = 500,000$  tons; Central plants:  $(2,000,000 - 500,000)$  tons  $\times 2,000$  lbs/ton  $\times 8,000$  Btu/lb  $= 24 \times 10^{12}$  Btu  
 $50,000$  homes  $\times 60,000$  Btu/hr - home  $\times 4,000$  hrs  $\times 50\%$  total system efficiency  $= 24 \times 10^{12}$  Btu.



resource numbers are off by a factor of five, there is still sufficient renewable energy for 20,000 homes. One object of the program is to define the resource.

The present cost of natural gas delivered by the utilities in the state is around \$2 per million Btu. The cost for electric or fuel oils is about two to four times the cost of natural gas. The cost advantage of natural gas is significant, and any centralized heating plant using biomass cannot compete with natural gas delivered to the homes for heating as presently priced when fuel and capital costs are considered. There does appear to be a strong possibility that biomass would be cost competitive with electricity and fuel oil. The communities in Montana that should be considered for the demonstrations are therefore those without natural gas. In addition, because the cost of a hot water distribution system is expensive, the communities must have a relatively high density business and housing area.

As in the case of the other programs, the development steps follow in order, such that if at anytime it is determined that the concept would not be cost competitive to existing systems, the program can be terminated without additional cost. Because of the existing technology base, very little hardware development and testing will be required. By the time that large hardware expenses are necessary, the system costs will be known, and a go/no-go decision can be made on an economics basis. This program therefore requires only a commitment of money on a step-by-step process. The state will be in the position to stop the program if at any time the system's technical or operational cost goal cannot be met. In addition, the selected communities will be expected to make a cash or in-kind contribution of at least 10 percent of the installed system cost.



An example of the sequence of steps that must be accomplished is:

1. Identification of communities in Montana that are interested in such a centralized heating concept;
2. Preliminary study of community energy needs;
3. Identification and quantization of renewable biomass resource in region;
4. Study of collection, processing, storage, and transportation methods that are possible;
5. Preliminary design of heating plant and distribution system;
6. Initial estimate of cost for delivered heat to users;
7. First decision by community to continue program;
8. Selection by state of communities that will receive further state support;
9. Decision by community on ownership and operational concept of heating plant;
10. Detail study of fuel costs aimed at minimizing capital and operational costs and maximizing return to land owner;
11. Layout design of heating plant and distribution system;
12. Commitment for required fuel supply at negotiated price;
13. Second estimate for cost for delivered heat to users;
14. Study of home and business heating unit costs and financing amount and method that will be required;
15. Second decision by community to proceed;
16. Sign-up of prospective customers;
17. Detail design of heating plant and distribution system along with continued work on fuel collection, etc.;
18. Final community approval on project;
19. Construction;
20. Plant and distribution system check-out;
21. Home and business hook-up; and
22. Operation.



It is proposed that four communities be selected for support through construction and check-out under this program with at least one using forest and one using farm biomass. Two would be started and would enter the construction phase before the second two would be selected by the state. The first two plants would be operational before construction on the second two plants would be started. Steps 10 through 21 will require about 20 months. Additional communities would be supported through step 17 if there is interest.

During the course of this program, the technical design, fuel processing, construction, and operational skills would be developed within the state, so that additional interested communities could develop their own plants through the established commercial capability.

The hot water distribution system developed under this program is quite similar to that proposed under the geothermal program. The community-size biomass heat plant technology is an excellent addition for any community that develops a geothermal supplied heat system that goes dry after 10 or 20 years.

The second element to be considered under this program is direct research and development support to furnace and stove manufacturers and biomass fuel processors. Improved stove and furnace design for lower manufacturing costs, improved efficiency, and pollution minimization must be developed. This must be done in conjunction with a detail study of the collection and processing of biomass fuels for direct home and business use. Fuel preparation and delivery costs must be minimized. The owner is buying Btu's, not



just a stove and fuel, and the whole business structure must be analyzed and developed within each community to provide this at minimum cost. Any expanded use of biomass will not come about by a significant increase in the weekend family trips to the woods to cut a load of firewood for the pick-up. For expanded use, the process must be commercialized with the resulting capital equipment and small businesses being established.

This stove and furnace program will directly support the passive and active solar heating programs that have already been supported by DNRC. In Montana, a biomass burning back-up heating system is ideal. Two to three tons of biomass fuel per year should be more than adequate for any properly designed solar home.

#### Resource and Need Assessment

In western Montana, the forests provide an extensive renewable biomass resource. As an example of the state output in 1976, twenty-five percent of the harvested roundwood products came from Lincoln County, 19 percent from Flathead County, and 13 percent from Sanders County. Four communities in this area without natural gas are Libby, Eureka, Thompson Falls, and Polson. Six hundred and sixty million board feet were harvested from these three counties in 1976, which is slightly lower than the average harvest over the past ten years.<sup>4</sup> There has been a general trend of decreasing harvest from public lands which is the major acreage in these counties during the past ten years; therefore, the harvest in this region might not be expected to be increased.

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R. V. White and C. E. Keegan, Ibid.



An average of the forest types and harvesting methods in a USDA Research Paper<sup>5</sup> on the northern Rocky Mountain region indicates that 5,000 ft<sup>3</sup> are harvested per acre, that after harvest, 35 tons/acre of residue in fines remain and three inches and greater are left on the ground. Computing the total acres harvested using the average yield per acre and the annual production gives 22,000 acres, with a biomass residue of 770,000 tons. This residue has a Btu content of  $10^{13}$  Btu. Furthermore, if it is assumed that only one-half of this residue is collected and processed, this gives a total of  $5 \times 10^{12}$  Btu available per year from these three counties.

In 1970, there were approximately 80,000 people in these three counties; of which, say 20,000 are serviced by natural gas. At three people per home, the remaining occupy 20,000 homes. An estimate of heat need would be 60,000 Btu/home for 4,000 hours/year, or a total heat need of  $4.8 \times 10^{12}$  Btu. Thus, the biomass supply is approximately equal to the need for home heating when only one-half of that available is collected. If 770,000 tons are sold to the home and central heating plants at a cost of \$30 per ton, this would represent an economic activity of \$23 million per year for the local economy within these three counties. The \$30 per ton is about \$2.15 per million Btu and is equivalent to electricity at seven mils per kilowatt hour, or fuel oil at 32¢ per gallon.

The biomass resource in this region can certainly be a cost competitive fuel if it can be delivered at \$30 per ton. One significant factor in

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<sup>5</sup> R. E. Benson and C. M. Johnston, "USDA Forest Service, Research Paper INT-181: Logging Residues Under Different Stand and Harvesting Conditions, Rocky Mountains."



determining whether or not this would be possible is the price of transportation which depends upon the harvest area and the use areas within these counties. One of the first steps of the program is to identify specific interest within the state. The four cities mentioned represent about 8,000 people or maybe 2,000 to 3,000 homes and businesses that could be heated by centralized hot water systems. There is certainly ample forest waste available on an annual basis to supply these homes.

In the grain growing regions of central and eastern Montana, a renewable resource equivalent to the quantity of forest biomass is available. The principal crop products of Montana are wheat and barley which, as an example, accounted for over 200 million bushels in 1975. The majority of the straw from this grain is presently marketed, plowed back, and used by the farmer in some beneficial manner. There is a real need for much of this straw; however, since it must be disposed of before a new crop is planted, disposal is more important than efficient use. What is implied here is that if there was another cash market for straw then some portion of that which is presently available could be made available for this market. The variation in the straw grown from one year to the next is sometimes as high as 1,000 pounds per acre or about four million tons statewide.

On the Highwood bench east of Great Falls, there is a 100,000 acre area on which year around wheat farming is practiced. The soil and climate conditions are such that the straw remaining after the wheat harvest cannot be plowed back into the ground. This straw must be removed from the ground in the couple of weeks between harvest and planting. There is not a sufficient



local market to use the available supply; therefore, this straw is "disposed of" in the easiest manner possible. As a renewable energy resource, this straw, at an average of one ton per acre, represents  $1.4 \times 10^{12}$  Btu annually, which could satisfy the heating needs of approximately 20,000 people, assuming an overall heating system efficiency of 60 percent.

The cost for baling and collecting straw from wind rows in the field after harvest has been computed<sup>6</sup> to be \$4.15 per ton, plus an additional charge of \$2.70 per ton for hauling to the edge of the field (one mile is the assumed average distance per trip). These baling and hauling costs of approximately \$7 per ton are for large round bales; the small rectangular baling costs are \$12 per ton.

Straw can be burned directly as collected from the fields; however, for any widespread use involving long hauling, this will probably not be economical. (This conclusion should be verified by further study to determine the critical hauling distance at which densification of the straw becomes economical). There are many processes by which straw can be compacted<sup>7,8</sup> to 55 lbs/ft<sup>3</sup> which is about the same as coal. In this densification process, the straw is usually pellitized to uniform size and dried to 10 to 12 percent moisture, making it a fuel which is very competitive in Btu content, combustion, and handling characteristics to western coal. In addition, the pellets have increased resistance to moisture absorption. The energy input for the complete processing is estimated at eight percent of the

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<sup>6</sup> J. D. P. Partridge and D. G. Hodgkinson, "Manitoba Crop Residues as an Energy Source," Proceedings of Forest & Field Fuels Symposium, October, 12, 13, 1977, Winnipeg, Canada.

<sup>7</sup> J. LaRue and G. Pratt, "Problems of Compacting Straw," Ibid.

<sup>8</sup> R. K. Broeder, "Successful Marketing of Pelletized Field Residues," Ibid.



energy in the straw.<sup>9</sup> The total operating and capital cost of the densification plant has been estimated to be between \$9 and \$10 per ton.<sup>9</sup>

The straw densification plant considered above for the 10<sup>5</sup> tons on the Highwood bench area would have to operate 333 days to process the total tonnage available. During the course of the year, the straw could be transported from the edge of the fields to a central plant in the region. This transportation cost would add another \$4 per ton to the final straw cost. Assume that bulk hauling of the pelitized straw in 20 ton trucks for a one-way distance of 50 miles would add another \$5 per ton, this gives a delivered cost of processed straw of \$25 per ton. Assuming the farmer is paid \$5 per ton in the field, the price of the straw 50 miles away ready for combustion would be about \$2 per million Btu. This represents a competitive price for fuel in many regions of Montana. One of the first elements to consider under this program is the refinement and verification of these calculations. In addition, other farming regions need to be identified that could provide a dependable, renewable biomass resource that could be used by a community or sold to individuals for their own private heating system.

#### Technical and Development Issues

The program objective is to determine the economic feasibility of biomass as a fuel in homes, businesses, and central heating plants. There

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<sup>9</sup> T. B. Reed and B. Bryant, "Energetics and Economics of Densified Biomass Fuel Production," Solar Energy Research Institute Report.



are no critical technical unknowns in this proposed concept for the direct combustion of biomass. Certain steps in the process are well understood, and the equipment and technology are fully developed with little possibility of improvement. At the farming/forest end of this process, probably the least cost effective steps are in collection and densification. This represents 2/3 of the costs in the straw example illustrated. These two processes have not been examined by any equipment manufacturer to date, and there may be a possibility of reducing the cost. Transportation (most probably done by truck) costs to the combustion site and storage costs are well established. Central plant combustion is well characterized, and the technology exists to meet all pollution standards at the same combustion efficiencies of coal. Although the majority of the designs for the present direct combustion home-size heating units have been around for years, there is considerable need for improvements in combustion efficiency and in minimizing emissions. These two factors become more critical as more and more units are installed and as weatherization programs make homes more air tight. Research and development work in these areas, using Montana fuels, will be necessary and can be accomplished at DNRC's supported Anaconda Combustion Facility.

The first issue that must be resolved for any community interested in a heating plant or widespread usage of individual heating units is to identify a dependable renewable energy supply. In the case of farming activities, this is easy; however, in the forest regions, the distances between harvest and combustion site will vary from year to year, and this variation must be fully explored and considered in determining lifetime costs of any system established.



Probably the single most costly item of a central plant system is in the hot water distribution system. There are a few examples of this in the U.S., e.g., the Boise, Idaho geothermal system, which can provide cost estimates. The more numerous and furthest advanced technically are those in the European and Scandinavian countries. In the small towns of Montana, this may be the one factor which will prevent the central plant concept from being cost effective. Extensive study and a conceptual hot water distribution system design for a representative town must be initiated at the start of the program.

The ownership and operation of a community-size plant are issues that must be resolved by each community individually since the ten percent cost or in-kind contribution are closely related to these issues. Of equal concern to the possible hot water users is the cost of home installation of heating units and what to do with the existing heating systems. Another point that needs to be considered by the community is whether or not the central plant will be operated year around or just in the cold months.

For an individual home or business use of biomass for heat, there are fewer economic questions. The major issue today is in establishing enough users in one region to justify the cost of the collection and densifying equipment. Assuming that an average home would use six tons of biomass per year, the Highwood bench straw processing facility example would provide biomass for 16,650 homes. Smaller processing plants and the use of fewer tons of straw will certainly have to be studied if only direct home combustion was used, since the signing up of that many customers initially would be doubtful. The advantage of central heating plants for towns and individual



heating units in the less dense living areas is certainly apparent if the maximum use of a region's renewable resource is to be made.

During the early stages of the program, all critical issues will be studied, and costs will be determined. If the projections are favorable, detail design of facilities and equipment will be made, and any required development programs will be undertaken. Communities and individual businesses interested in biomass fuel marketing and equipment marketing and servicing will be supported to the maximum degree possible. Direct support of a large-scale project will be provided once economic feasibility has been established. Each step must be justified on the projected economic feasibility, and if this cannot be done, the program is redirected or terminated.

#### Additional Issues

The central heating plant concept may be in the area of a community utility. The legal implications of this need to be fully explored.

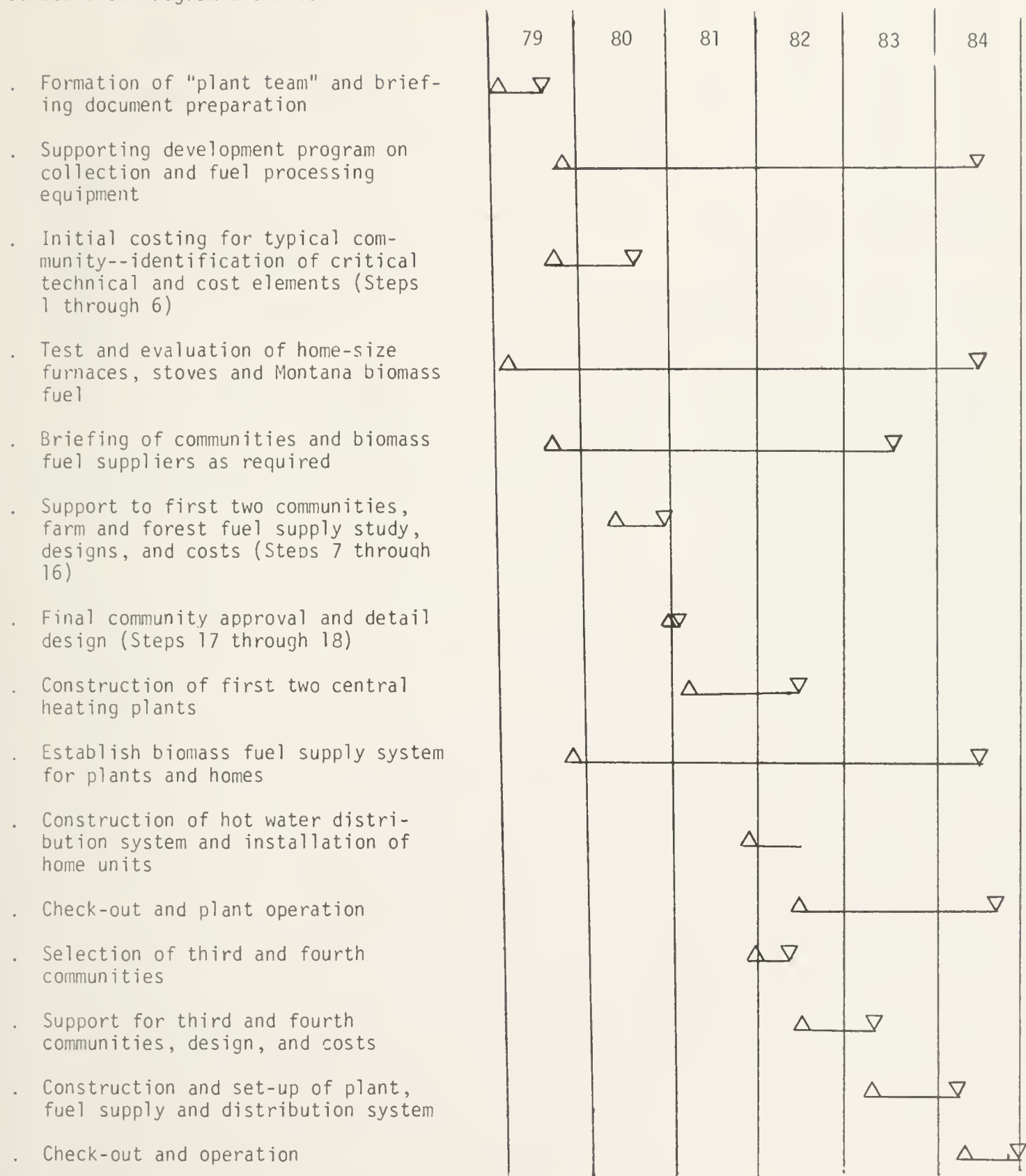
If new farm/forest equipment is required, Montana firms or national farm equipment firms should be encouraged to establish manufacturing plants in Montana for this equipment.

Tax incentives to businesses supplying renewable fuels could be considered.



## Schedule and Cost

### Schedule of Program Elements





Major Cost Categories by Years (Dollars in Thousands)

|   | 79  | 80   | 81   | 82   | 83   | 84   |
|---|-----|------|------|------|------|------|
| . Biomass combustion plant team   | 350 | 350  | 300  | 300  | 200  | 200  |
| . Test and evaluation of home-size units and fuels  | 200 | 200  | 200  | 200  | 100  | 100  |
| . Plant and distribution system design  | 0   | 0    | 145  | 0    | 400  | 0    |
| . Plant and distribution system construction (additional financial support from communities required) | 0   | 0    | 1200 | 1650 | 2550 | 4850 |
| . Biomass fuel supply equipment development   | 60  | 150  | 200  | 225  | 160  | 150  |
| . Support to fuel supply "companies"  | 40  | 100  | 150  | 175  | 200  | 100  |
| Total Cost  | 650 | 1355 | 2195 | 2450 | 3610 | 5400 |

It is proposed that the yearly costs are shared between state and federal government at a one to five ratio.



## BIOGAS GENERATION SUBPROGRAM

### Introduction

There has been national and international interest and activity in the generation of biogas (approximately 65 percent methane, CH<sub>4</sub>) from municipal sewage and animal manures since before World War II. Both community and large dairy farm size facilities exist in the United States. In addition, units down to the size of 50 pounds of manure a day exist in other countries. Biogas generation is not in widespread use in Montana; however, there are numerous facilities in other northern states.

The DNRC has supported a study on the potential in Montana for biogas generation, and there appears to be three sizes of facilities. The smallest is for the generation of a few hundred cubic feet of methane per day for home and farm/ranch building space and hot water heating. The next larger unit is that associated with a dairy or cattle feeding activity and would use the manure from a few hundred cattle to supply the gas for all heating needs for the activity and surrounding homes or small businesses. The last facility is one that would use municipal waste and possibly agricultural or forest residues. Montana communities without natural gas service and with additional biomass residues are the most likely candidates for the first facilities of this size.

### Available Technology

The basic principles of biogas generation or methane fermentation, also called anaerobic digestion, are widely used in modern sewage treatment plants and involves the decomposition of organic matter in an oxygen-deficient atmosphere. The process involves three stages: first the proteins, carbohydrates, and fats are dissolved; next, non-methanogenic bacteria convert



the soluble organics into organic acids; and last, methane-forming bacteria reduce the organic acids and other oxidized compounds to methane ( $\text{CH}_4$ ) and carbon dioxide plus traces of other gases. The process is usually maintained at 95°F for optimum performance but biogas can be generated between 40°F and 140°F. The equipment required is simple: feed mixer, pumps, piping, and reactor tank. The overall conversion efficiency is dependent upon the degradation of the volatile feed material and for certain materials and facilities it is as high as 60 percent.

In addition to the biogas produced, the degradation of the feed material can transform the organic nitrogen into ammoniated nitrogen to yield a more stable residue for application as fertilizer or soil conditioner. For the small ranch or farm digester, with cattle manure used as the feed stock, the process improves the value of the manure as fertilizer.

Additional research into the digestion process and economic analysis of components and different combinations of feed-in and fertilizer-out are needed before the optimum designs for use in Montana will be known for small size facilities. Design and cost information are better known for community size sewage facilities.

#### Program Tasks

The majority of the program activity will be directed toward the farm, ranch, cattle feed lot, and dairy farm use. In the area of large facilities, a study will be made of communities for municipal size biogas generation. The key elements of the study will be the community need and the additional biomass waste available. Adequate large scale technology exists so that minimum research and development is required. Design trade offs with emphasis on total system costs, including community participation, will be performed.



Selection will be made of one community in Montana for the construction of a biogas generation facility and methane distribution system. As in the other community scale renewable energy subprograms, the community will make the final decision and state financial support will be limited to system studies, design, and up to 90 percent of the actual cost of construction.

In the range of the middle size facilities, support will be provided for two facilities. Hopefully, one dairy farm and one feed lot size facility can be found. Interested individuals and organizations will be asked to submit a request for consideration. The program will provide initial design and cost estimates as requested. The selection of the two facilities to be supported will be based upon the applicability and appropriateness of the facility as a demonstration in Montana and the amount of construction cost sharing provided by the owner. Additional research and development of components and processes may be required in support of specific design problems during the course of this segment of the program.

For the small scale farm or ranch digester supplied by 25 to 100 cows, a development program is necessary. At the present time, the most appropriate design for the Montana environment and farming practices is unknown.

Trade off studies followed by equipment development and testing need to be performed. Such questions as the relative benefits between insulation and digester heating during cold weather operations must be answered. The correct digester size as a function of feed and service time, fertilizer use, and methane gas need must be determined. Flexibility in digester loading is important so that variable output can be obtained from any one design. The number of designs and the interchangeability of components between designs must be considered so that advantage can be taken of mass production.



Information will be collected and analyzed from Montana farmers and ranchers to determine the appropriate design for maximum use in the state. From this information, a design will be developed that will emphasize minimum total system cost. The labor in feeding the digester series of digestors will be manufactured and tested, and during the course of the program three models will be made. Each succeeding model will include design improvements. Two digestors using the first design, five using the second, and finally twelve using the final design will be manufactured and tested. Farmers and ranchers will be asked to participate in all testing. The necessary test instruments and digestors will be provided at minimum cost for the first two models. Additional cost support will be expected from the farmers and ranchers who are selected for the twelve digestors made with the third design.

An important factor that must be considered is that the capability for commercial manufacture of the digester, once the best design has been determined, must also be developed during this program. In addition, design engineering capability in the state must be developed for the larger biogas systems through this program.

#### Additional Issues

The community size waste facility that generates and distributes methane from biomass and waste will be a "utility". Under the present state laws, this could be a problem.

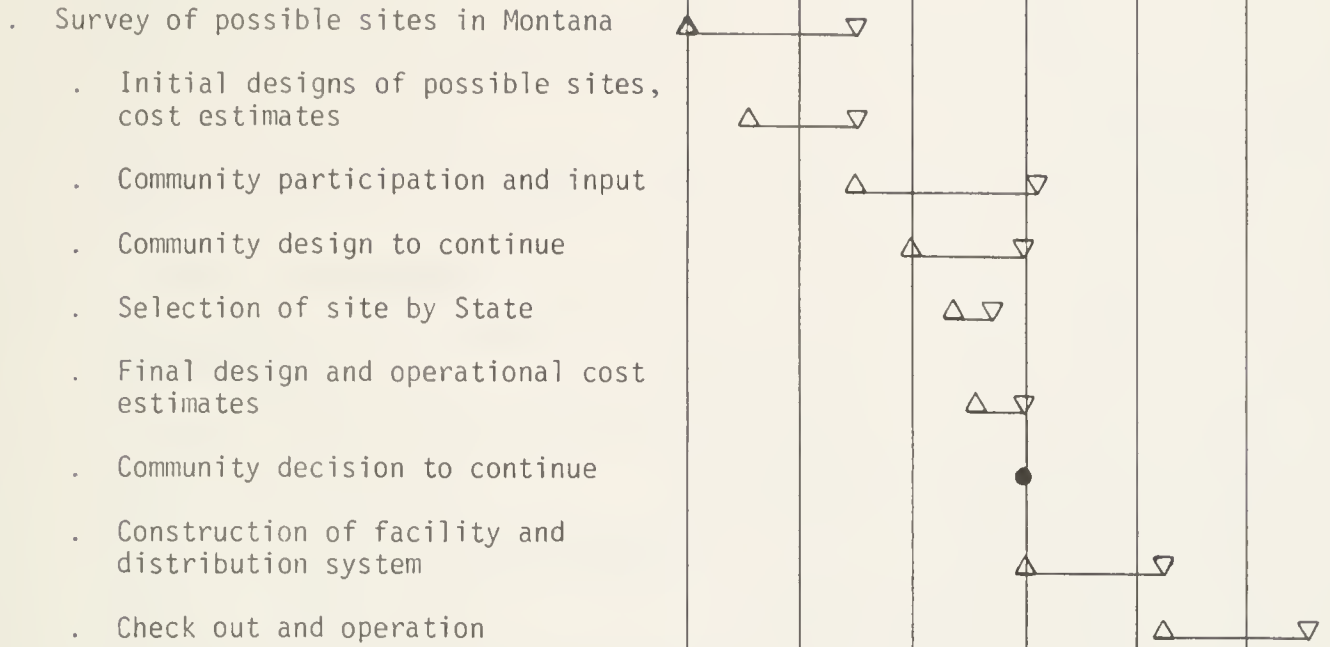
There are research and development activities in biogas throughout the country and the world. This program must keep pace and make use of appropriate results from this extensive work.



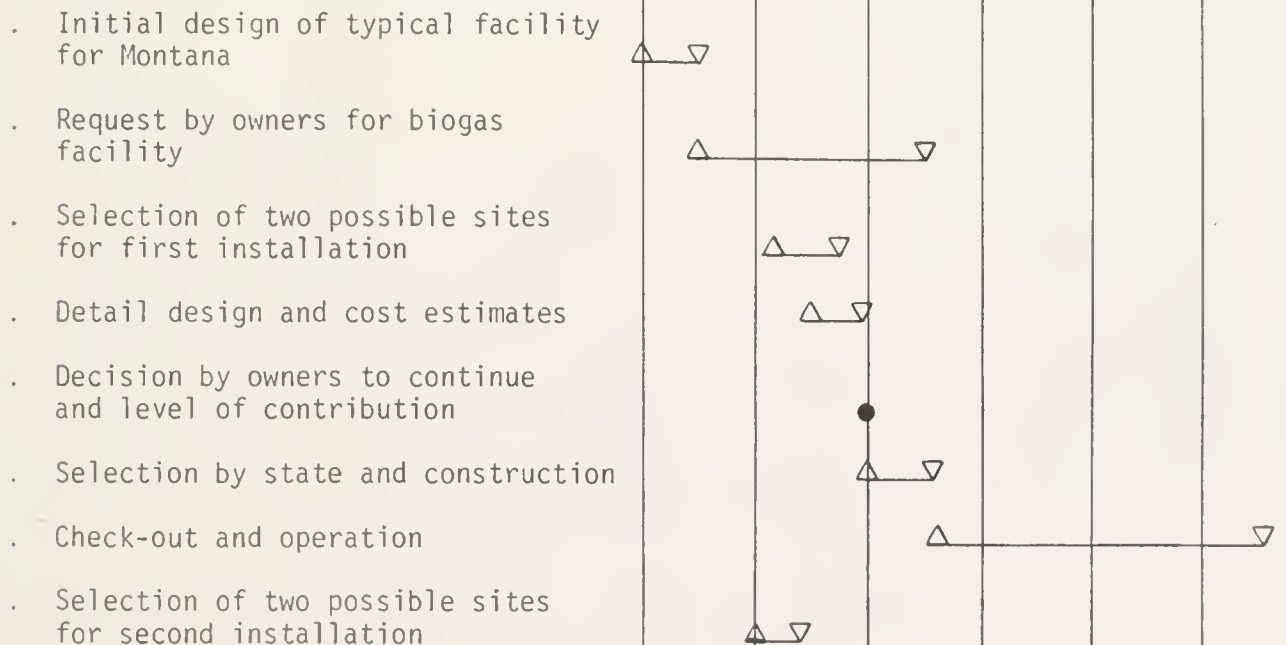
## Schedule and Cost

### Schedule of Program Elements

#### 1. Community methane generator

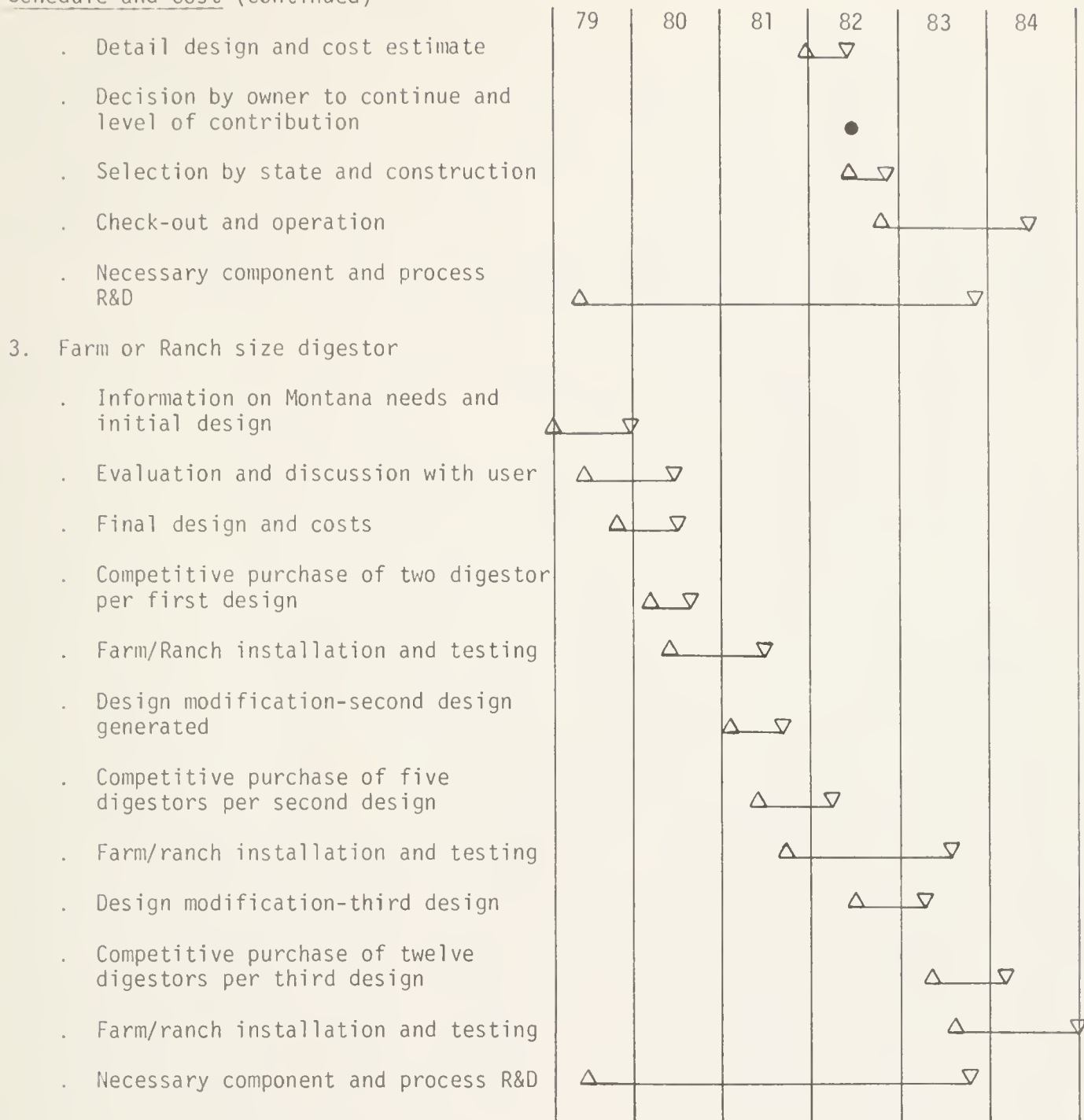


#### 2. Feed lot/dairy farm facility





## Schedule and Cost (continued)





| Costs (Dollars in Thousands)    | 79  | 80  | 81  | 82  | 83  | 84  |
|---------------------------------|-----|-----|-----|-----|-----|-----|
| 1. Community methane generator  | 50  | 65  | 120 | 500 | 290 | 100 |
| 2. Feed lot/Dairy farm facility | 75  | 85  | 155 | 190 | 205 | 200 |
| 3. Farm or Ranch size digester  | 75  | 150 | 175 | 210 | 190 | 300 |
| Total Cost                      | 200 | 300 | 450 | 900 | 685 | 600 |



## WIND ENERGY SUBPROGRAM

### Introduction

The Department of Energy's wind program has received increased funding during the past years and has \$60 M for FY79. The major objective of the national program is developing the technology for small and large wind generators and the methodology for wind energy assessment. Montana can benefit from the "base" provided by the national program, but in order to make wind generation a reality in Montana, much remains to be done. It is not realistic to expect private investment to cover all of the costs.

Presently, wind generators cost anywhere from \$300 to \$2,000 per rated kilowatt generated (depending upon rated output and design wind speed) plus installation costs. One important reason for this cost is the limited number of wind generators manufactured to date and the "handcrafting" of the components. During the past few years, less than 100 wind generators of greater than 15 KW capacity have been manufactured. Comparing the technology, individual components, and operating environment of a wind generator to that of other systems that are mass-produced, the present prices of the few available models seem higher than would be necessary under mass production. If generators were sold at \$200 per kilowatt, a 25 KW generator costing \$5,000 installed at Great Falls would generate \$2,000 in electricity @ 2¢ per KW/hour in an average year.

A relatively small amount of state funds can stimulate the wind electric generator industry in Montana and establish a leading position for the state in the manufacture of wind generators in the United States. Once



established, this manufacturing capability would have as its marketing area the northern Rocky Mountains and Great Plains region--an area in the United States that represents a significant wind energy region--and one which may be exploited first due to the existing land ownership patterns, established electrical grid network, and the large amount of hydroelectric generation.

Contributions to the wind program have been made by previous Department of Natural Resources and Conservation (DNRC) funded projects. Limited wind potential assessment, measurements, wind generator manufacturing, and small-scale wind generation operational experience has been gained. The U.S. Department of Energy's (DOE's) wind program has advanced to the point where Montana can take advantage of the program results. This coming year, 1979, is the time to expand the wind program in Montana because of the status of the federal program and the projected electric energy needs for Montana by the mid-1980's.

#### Resource Assessment

The United States DOE has estimated the average annual wind energy potential in Montana as 250 to 400 watts per square meter of wind.<sup>1</sup> Projecting this into electrical generation capacity and using only one percent of the land area in Montana, over 5,000 MW could be generated. As a comparison, the feasible extraction limit of wind energy within the United States for the generation of electricity has been estimated to be equal to the total energy used in the United States in 1977.<sup>2</sup>

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<sup>1</sup> BNWL-2220 Wind 5, July 1977, Battelle Pacific Northwest Laboratories.

<sup>2</sup> "Wind Energy Resource Parameters," M. R. Gustavson, Proceedings: National Conference on American Wind Energy Association, March 1978.



The wind potential in Montana is divided into two general regions. Western Montana is characterized by high peaking winter winds; whereas, the winds in eastern Montana are more constant throughout the year. The western region wind energy will combine well with hydroelectric generation, which peaks in the summer, to provide a year-around renewable energy resource. In western Montana, existing and small-scale hydroelectric (either low or high head) projects for which the technology exists can be developed to match a portion of the wind-generated electricity. Significant wind energy exists in eastern Montana, although in general, the yearly average is less than for western Montana. As an example of the potential, Glasgow in northeastern Montana has approximately 70 percent of the wind energy potential of Clayton, New Mexico, the site where the DOE installed their first large generator. Wolf Point, Montana has almost 80 percent of the Clayton site. Current studies are underway by the Corps of Engineers to use hydroelectric generation as peaking electricity. This concept would work well with a large wind generation system.

The area along the Yellowstone River between Livingston and Big Timber has been rated by DOE as the number two area in the United States for wind energy potential. Whitehall and Great Falls are also rated in the top twenty-five in the United States.<sup>3</sup> This rating was established by using data from weather stations and is limited to fourteen towns in Montana. Additional data from utilities and the USDA is also available. Information must be gathered from every county in Montana with suspected adequate wind

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<sup>3</sup> "Wind Power Climatology of the United States," Jack W. Reed, SAND74-0348, Sandia Laboratories Energy Report.



energy to generate electricity. This will be done early in the program to further expand the existing data base. Only the better sites will be selected initially for the installation of generators to provide a maximum available positive cost "cushion" for the first wind systems. Once design, fabrication, and operational improvements have been made, systems can be installed throughout Montana at sites with lower wind energy potential.

The table below gives the average annual wind energy from the 14 sites listed for Montana.

Montana Average Annual Wind Energy

| <u>Site</u>          | <u>Watts/Meter<sup>2</sup></u> | <u>Maximum Month</u> | <u>Minimum Month</u> |
|----------------------|--------------------------------|----------------------|----------------------|
| Glendive             | 149.5                          | 222.0                | 111.4                |
| Miles City           | 115.2                          | 161.9                | 87.8                 |
| Wolf Point           | 179.9                          | 326.4                | 124.2                |
| Glasgow              | 133.0                          | 198.6                | 101.7                |
| Billings             | 173.9                          | 237.2                | 99.0                 |
| Livingston           | 500.5                          | 1058.7               | 233.7                |
| Lewiston             | 140.8                          | 198.4                | 82.4                 |
| Havre                | 114.7                          | 155.4                | 74.9                 |
| Great Falls IAP      | 304.5                          | 509.4                | 136.3                |
| Great Falls Malstrom | 169.3                          | 263.8                | 80.1                 |
| Helena               | 90.6                           | 145.5                | 34.9                 |
| Whitehall            | 344.7                          | 710.4                | 167.7                |
| Butte                | 104.8                          | 158.7                | 76.8                 |
| Missoula             | 50.1                           | 75.8                 | 19.5                 |

The extreme western portion of Montana probably has low wind energy potential in the valleys but could have significant wind potential on mountain ridges or at elevated heights. These sites may not prove economical because of high siting costs.



## Commercialization

It is important to understand what is meant by commercialization of wind or any other energy source.

Within the Northern Great Plains and Northern Rocky Mountain region there are projections for increased electric generation capacity of 5,000 to 20,000 MW and greater by the year 2,000.<sup>4</sup> "Commercialization of wind" encompasses a plan and program that will enable wind-generated electricity to provide as much of this increased capacity as possible. To be competitive with other generating systems, the cost of wind generators at the factory must be close to \$300 per kilowatt in 1978 dollars since wind generators have a lower capacity factor than conventional generating facilities. A typical design objective for a wind generator would be to obtain a 40 percent utilization for a "standardized" average 12 mph wind.<sup>5</sup> Higher capacity factors at lower average winds are possible, but the cost per kilowatt generating capacity would be higher. There are cost advantages for wind systems--low site construction costs, shorter construction periods, and no fuel cost--all of which will be needed in order to make these systems competitive, especially with mine mouth coal generating plants. Cost disadvantages include higher maintenance costs due to number of units and their dispersed locations and higher utility grid hook-up costs. The initial capital cost per kilowatt generating capacity must be low, and this can be greatly enhanced by mass production. As pointed out earlier, wind generation

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<sup>4</sup> BPA and Missouri River Basin Estimates.

<sup>5</sup> Design Study of Wind Turbines, 50 KW to 3,000 KW, ERDA/NASA/9403-76/2, General Electric Company, December 1976.



couples best into a generation system that has a high percentage of hydro-generation. This coupling can enhance the relative value of both systems.

Thus, commercialization includes the establishment within Montana of the capability for wind energy assessment, manufacturing, installation, maintenance, repair, and energy utilization. This must be done in great part with private resources; however, the state can stimulate and support the critical early market for wind generators when the cost per machine is high and the generation is a marginal economic activity. In addition, commercialization includes establishing the acceptance of wind generators in Montana and encouraging the purchase of generators by individuals and utilities. If one assumes a figure of one man-year of manufacturing per 100 KW and one man-year of installation, control, maintenance, and repair per 10 MW generating capacity per year, along with the assumption that 5,000 MW would be manufactured and installed in Montana and neighboring states, then a significant economic return is possible. The manufacturing and support businesses for this number of wind generators would generate about 3,000 jobs that would continue through the year 2,000. The last element of commercialization is insuring the landowner benefits directly and adequately as a function of the generated energy value, and not simply for bearing the inconvenience of the generators on his land. A statewide generating system selling power throughout the region could generate revenue for Montana farmers and ranchers.



## Technical Program

There are two major divisions in the technical program because of the wind generator size--a farm or ranch size  $\sim$  25 KW and a utility size from 250 KW to a few megawatts. The final size/sizes will, of course, be determined by those sizes that provide the highest economic return. One major objective of the program must be to determine the optimal sizes for these two major uses. The current U.S. DOE sponsored designs for 40 KW generators probably represent the largest size a farmer can install with minimal help and maintenance by himself. This size generator is similar in size and complexity to other farm equipment. The large utility size in the few hundred KW to megawatt capacity will also be heavily influenced by the advantages of mass production, installation costs, total wind farm reliability, and small crew maintenance costs. The important point to remember is that, while for each specific need and location there will be an optimum size, customized generators cannot be manufactured at low cost. What is the best for Montana must be determined early in the program.

## Wind Energy Assessment

The DOE has collected and evaluated the recorded wind energy measurements from the National Weather Bureau and other government and private agencies. The result of this evaluation is that Montana appears to have a significant wind potential; however, these measurements are not of sufficient detail and accuracy to establish the good sites and the economic return from wind generators. A statewide effort to measure the wind energy in every county is needed. Twenty-five portable self-contained anemometer



systems, using 10 meter towers, will be purchased. These small towers will be moved around the state, and within a four-year period can map the wind energy potential with sufficient accuracy to establish the economic feasibility of farm and ranch size units. These stations will be installed by a combination of professional and local people with routine maintenance and data tape collection performed by local personnel. The high school science departments will be asked to participate in the program. All data will be reduced and evaluated at a central facility.

In addition to the 10 meter towers, five 30 to 50 meter towers, instrumented at two levels, will be installed at prime high wind sites across the state to determine the wind velocity profile and energy at potential utility wind farm sites. These towers will be installed and maintained by professionals, and this data will also be processed at a central facility. The first year of wind data will also be used in generator design and size selection.

Within four years, this mapping of the wind energy potential of Montana will provide the most comprehensive wind data base for any region in the world; however, it is just the minimum required to adequately assess the potential, design wind generators, and determine the essential electric generation economics for a region the size of Montana. In comparison with petroleum and coal exploration, projected costs for wind energy assessment are significantly less for the potential energy return.



## Operational Objectives

No basic research program on wind generators is proposed because this is being done under the federal program. The federal program is also supporting the manufacture of wind generators from a few kilowatts to megawatt capacity. The Montana program objective is to use this base created by the United States DOE and address specific technical and operational problems in Montana so that the economics of electricity generation on the farm and ranch and by utilities can be established. At the same time the economics are being determined encouragement and support will be provided to industries in Montana, so that once the optimum configurations and sizes have been established, production can be initiated. It is felt that only by using mass production methods will wind electric generators ever become competitive with conventional generators and be used for any more than remote site operations.

As mentioned previously, one question that must be answered is the proper generator size for the individual Montana ranch. A single generator size is not essential, but the fewer the number of models, the higher the return from mass production. In addition to generating capacity, the size will be influenced by installation and maintenance costs. It is also important to determine what size generator can be handled by the farmer/rancher and his help. The maintenance expense is one of the high costs of wind when compared to conventional systems. If this can be done by the land owner, in addition to his other work, wind electricity generated on the farm or ranch can be more competitive. It is necessary to test various wind generator



systems in Montana in order to determine the correct sizes and the maintenance costs and requirements. The correct generator size for the utility wind farms is a similar problem and must be determined by considering the same factors. Experience in the Montana environment is essential to determine operating costs in Montana.

An equally important factor is to determine the utility interface requirements for safety, local monitoring, control, and switching. The degree of difficulty will be different for each utility, although many technical problems will be common. Collection and distribution problems of each rural utility and its supplier must be worked out. In the next ten years, wind generated electricity can become a significant part of the rural utilities source; however, it will not be the most important source. The existing sources will still be the most important; therefore, the wind electricity must be smoothly worked into the existing system. The conventional generating and interconnected distribution system, along with wind generators located at the other sites, will provide the back up or storage system when the wind is not blowing in a specific location.

The purchase and installation of generators must be so scheduled that it answers the technical and cost questions and supports the development of the manufacturing and supporting businesses required to establish a wind energy industry in the state. Therefore, the operational objectives cannot be separated from statewide business objectives. Preference will be given to Montana-manufactured machines, and thus, out-of-state manufacturers will be encouraged to establish facilities within the state. Tax and other incentives should also be considered.



The first systems purchased will be thoroughly instrumented and detail operational maintenance and performance records maintained. Overall performance and economic value will be evaluated. This information will be made available to the manufacturer for any necessary corrective action. A series of machines will be purchased over a three-year period so that the manufacturer can plan and make improvements from model to model. At the end of the three-year period, it is planned that sufficient model iterations and numbers will have been manufactured so that mass production designs and costs are known, and the manufacturers can go into mass production.

#### Farm/Ranch Program

Over the three-year period, 40 to 60 farm and ranch size wind generators will be purchased from at least two manufacturers. The initial generators will be purchased and installed using 100 percent state funds. By the end of the program, the landowner will be expected to pay a small portion of the purchase price and all of the installation cost. DNRC has already supported one Montana manufacturer, and his generator will be installed this fall on a ranch or farm in Montana. During the three-year period, three to four model iterations should be possible with each model becoming less expensive. After the operational tests, each generator will be evaluated on performance and cost. The manufacturers with the most successful generators will be funded for newer models. The poorer performing generators will have to be improved at the manufacturer's expense and will be tested again under the state program if requested by the manufacturer.

The state will be establishing and developing the product and market by the continued refinement of the operational and performance specifications



for the machines purchased. This is an extremely important responsibility since it will define the characteristics of the generator the manufacturers are in a position to mass produce at the end of the program.

The federal small wind generator program being conducted at Rocky Flats in Colorado includes the purchase, testing, and evaluation of generators in the one to 100 KW range. The winds of the Rocky Flats site are such that frequent high stress conditions are induced; however, sustained moderate winds are not typical. An expansion of this federal program will include the purchase of two machines per state for testing within each state. Montana will participate in and benefit from this program. It is not DOE's intent to solve all the state specific problems with such a limited program, but rather to provide public wind generator awareness and visibility. The federal funds are doing much to stimulate manufacturers across the country, the Montana program will do even more and may cause some to move to Montana.

#### Utility Program

The federal large wind generator program supports the manufacture and testing of 200 KW and 2 MW generators. Five of the 200 KW size generator sites have been selected and have been or will have generators installed soon and a two megawatt size is scheduled for testing. All of these are government purchased machines with utilities sharing the cost of operation and testing. The testing and demonstration of large wind generators in Montana must be coordinated with the federal program. At the present time, there are no federally funded programs for the testing of large wind generators in Montana.



The critical unknowns in any utility size wind generator "farm" concept is the operational cost and total system reliability. Under the present federal program, there are no plans to develop this information anywhere in the United States, much less in a region with an environment similar to Montana. The Bureau of Reclamation has a plan to install up to five 2 MW size generators at Medicine Bow, Wyoming in the 1985 time period. Information from this project will come too late to be used in satisfying Montana needs; it may not have the most cost effective size generator, and it will not have an adequate number of generators to determine true "farm" operational and maintenance costs.

There is a problem of how to determine the most cost effective large size generator for a utility system. The larger machines are quoted at a lower price per kilowatt, although only limited numbers have been manufactured. There may be an advantage in purchasing large generators; however, the expense to determine the representative wind farm operational costs will be very large if 20 large 2 MW generators are used. The "utility" program proposed is to install a couple of 2 MW generators to determine the operational characteristics in the Montana environment, and a larger number of 200 KW machines to determine the total wind farm system costs. A federal agency will be sought to finance a majority of the cost of this program element. Utility participation will also be encouraged.

A 5 MW size wind farm using 200 KW size generators is proposed so that answers to some of the critical questions may be determined. This is the size of generator currently being built by the DOE and the large size wind



generator with the largest number manufactured to date. In order to have the government participation in the first wind farm in Montana, the site selected should be associated with government electricity generation. Areas of greatest potential are Ft. Peck Dam, Gibson Dam, Tiber Dam, or Yellowtail Dam. Studies are underway at all four sites for expanded electric hydro-generation (Gibson and Tiber have none at the present time). The wind energy potential is known only for the Ft. Peck Dam area; although from the surrounding terrain and climate conditions, Gibson, Tiber, and possibly Yellowtail could have significantly greater wind potential. Installing 5 MW capacity using the 200 KW size machines can be done sooner and cheaper than the proposed Bureau of Reclamation Medicine Bow demonstration. An extensive effort will be made to interest the government into installing a 5 MW wind farm in Montana as the first step in the utility program. In addition, a request will be made in conjunction with Montana utilities to the DOE to install two of their 2 MW generators at known high wind potential sites in Montana.

Once production and operational costs have been established in the Montana environment, the utilities can be expected to show interest if these systems are competitive with conventional generating plants. Wind farms can be constructed, generator by generator, and therefore have a gradually increasing generating capacity which is an important construction cost advantage. The direct financial contribution that can be made to the utilities under this program to establish their own wind farm is limited to wind energy assessment and system studies; however, tax and rate incentives



to the utilities are surely of interest and should be considered. The utilities should be encouraged and assisted in establishing 200 to 250 MW of generating capacity by the 1983 time period. As electricity demand grows, new installations should follow quickly at the prime sites across the state once wind electric generation has been proven competitive.

#### Site Selection Methodology

Any major utility wind farm will come under the state Major Facility Siting Act, and utilities would be expected to comply with this act and the established procedures. The proposed small government wind farm will be located at a site selected by the participating government agency. The individual farm or ranch size wind generator program has different site selection problems and would not come under the Major Facility Siting Act. The initial wind generators will be located on farms or ranches with high wind energy potential and where the performance monitoring costs will be minimized. In the early stages, a significant amount of "professional" time will be required at these installations. The farmer will be expected to contribute some time in routine maintenance. Later in the program, lower wind potential sites will be selected, and more contribution by the land owner will be expected. In general, in the early phase, specific ranchers and farmers would be asked to allow wind generators on their ranches or farms, and toward the end of the program, interested farmers or ranchers would "bid" for wind generators by sharing in purchase and installation costs and in operational monitoring and maintenance.



Farmers and ranchers have been used throughout in the program description; however, it should be noted that all land owners would be equally considered.

#### Additional Issues

Certain legal, technical, and economic issues can significantly contribute to the wind program. These are:

1. Early identification and selection of the optimum size for the wind generators. This will focus the manufacturing effort which at the present time is considering generators from 1 KW to 3 MW.
2. Wind right laws. Who owns the wind; is it similar to sun rights or water rights?
3. Possible tax credit for wind generator electricity purchase and use.
4. Possible requirement for utilities to first purchase farmer or rancher generated electricity at a fair return to the landowners and at a fair price to the utility recognizing their real costs. Some specific rate structure for wind generated electricity might be considered.
5. What are the environmental effects, visual, etc.?

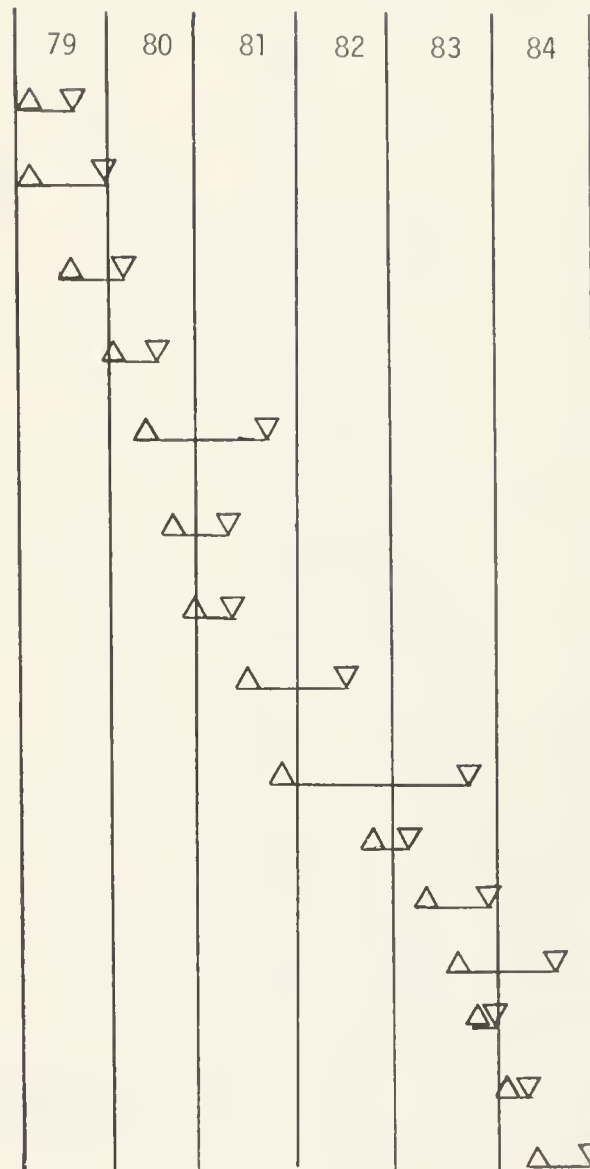
An early favorable resolution of these issues could certainly enhance and benefit the proposed program.



## Schedule and Cost

### 1.a. Wind Energy Assessment Schedule.

- . Site selection of 13 prime sites in state
- . Establish cooperative program with communities/schools around sites
- . Purchase of equipment: 10 small and three large tower systems
- . Installation on prime sites
- . Data collection and evaluation--check out performance of anemometer systems
- . Purchase of additional towers and systems (15 small and two large)
- . Selection of second sites
- . Installation of new anemometers (move older ones to second sites)
- . Data collection and evaluation
- . Selection of third sites
- . Installation of anemometers
- . Data collection and evaluation
- . Selection of fourth sites
- . Installation
- . Data collection and evaluation



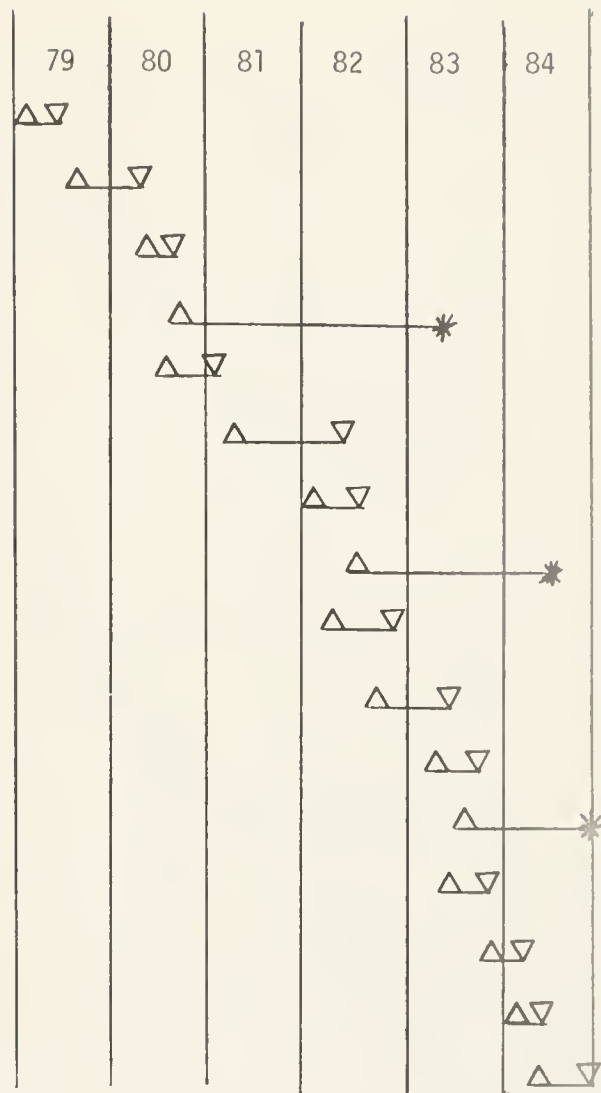
### 1.b. Wind Energy Assessment Cost. (Dollars in Thousands)

|  | 79  | 80  | 81  | 82  | 83  | 84  |
|--|-----|-----|-----|-----|-----|-----|
| . Site selection, data collection and evaluation | 90  | 140 | 200 | 200 | 200 | 60  |
| . Anemometer and tower equipment cost            | 105 | 100 | 90  | 0   | 0   | 0   |
| . Equipment installation and maintenance         | 40  | 40  | 110 | 150 | 100 | 40  |
| 1.b. Total Cost                                  | 245 | 260 | 400 | 350 | 300 | 100 |



## 2.a. Farm/Ranch Program Schedule.

- . Develop generator specifications
- . Purchase 5 generators (1st model)
- . Installation
- . Test and demonstration
- . Develop Specifications for 2nd model
- . Purchase 10 generators
- . Installation
- . Test and demonstration
- . Develop specifications for 3rd model
- . Purchase 20 generators
- . Installation
- . Test and demonstration
- . Develop specifications for 4th model
- . Purchase 20 generators
- . Installation
- . Test and demonstration



\* indicates end of state funding support, land owner required to continue supplying performance data for two years.

## 2.b Farm/Ranch Program Costs (Dollars in Thousands)

|  | 79  | 80  | 81  | 82  | 83  | 84  |
|--|-----|-----|-----|-----|-----|-----|
| . Develop specifications and monitor performance | 60  | 120 | 150 | 200 | 250 | 50  |
| . Purchase of wind generators                    | 90  | 150 | 250 | 325 | 470 | 225 |
| . Installation and maintenance                   | 70  | 70  | 100 | 200 | 130 | 180 |
| 2.b. Total Cost                                  | 220 | 340 | 500 | 725 | 850 | 455 |



### 3.a. Utility Program Schedule

Montana Federal Site (5 MW @ 200 KW each)

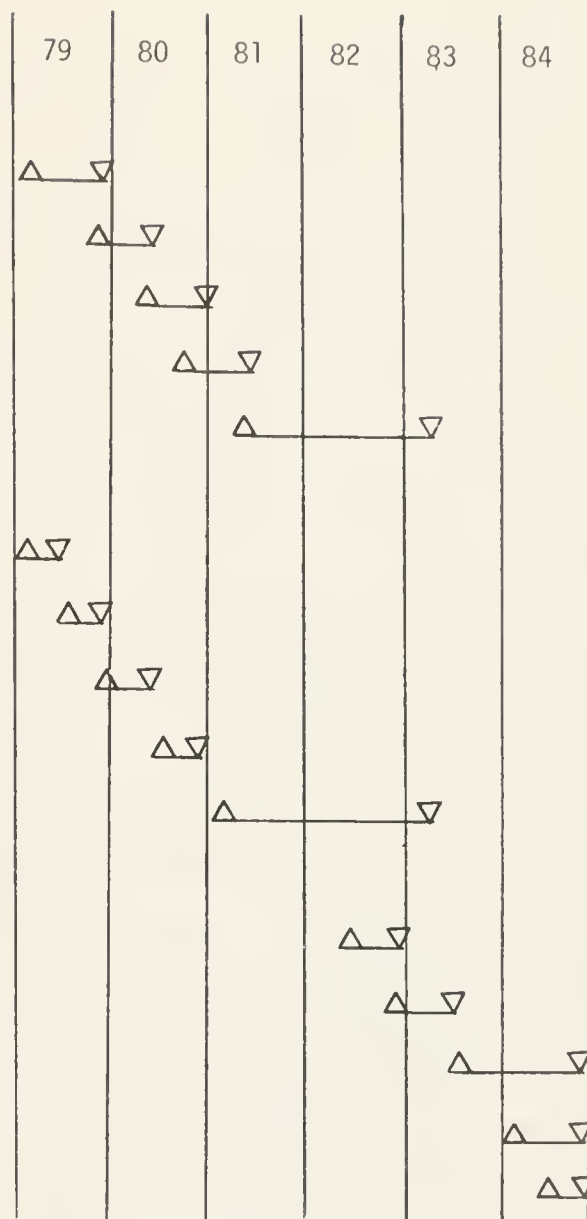
- . Site selection
- . Site design
- . Manufacture of generators
- . Installation
- . Testing

Montana Utility 2 MW Site

- . Site selection
- . Site design
- . Manufacture of generator
- . Installation
- . Testing

Montana Utility (25--200 MW Site)

- . Site and generator selection
- . System design
- . Manufacture of generators
- . Installation
- . Generation



### 3.b. Utility Program Costs (Dollars in Thousands) State Funds Only

- . Participation in site selection, design, and generator selection
- . Site evaluation

3.b. Total Cost

Total Cost 1.b. + 2.b. + 3.b.)

|  | 79  | 80  | 81   | 82   | 83   | 84  |
|--|-----|-----|------|------|------|-----|
| Participation in site selection, design, and generator selection | 75  | 90  | 75   | 75   | 50   | 0   |
| Site evaluation  | 85  | 90  | 75   | 50   | 0    | 0   |
| 3.b. Total Cost  | 160 | 180 | 150  | 125  | 50   | 0   |
| Total Cost 1.b. + 2.b. + 3.b.)                                   | 625 | 800 | 1050 | 1200 | 1200 | 555 |



## GEOHERMAL SUBPROGRAM

### Introduction

The use of geothermal heat, usually directly from hot water or steam, is considered to be a renewable energy resource. Whether or not this is true depends upon the source, the period of time, and the use rate. The heat content of the earth's near surface is certainly very large, and if the water resource is not depleted by use, the energy resource available is large compared to conventional nonrenewable resources.

The present United States Department of Energy (DOE) geothermal program is structured more closely to the needs of Montana than any of the other federal energy programs. There is an extensive effort in resource assessment and, even more significantly, in geothermal demonstrations. Use of geothermal hot water for space heating is widespread around the world, although not extensive in total amount of energy delivered. One of the earliest modern commercial residential systems is that of Boise, Idaho, which was established in 1890. This geothermal resource has been selected along with other across the United States (Warm Springs State Hospital in Montana) as a demonstration project for expanded use of geothermal resources. In addition to space heating, the DOE is interested in supporting demonstration projects in agricultural and industrial use of geothermal resources.

Montana possesses significant, known geothermal resources, and there is a high probability that larger resources are available across the state. The surface flow rates of the hot springs vary from a few gallons per minute to a thousand, with temperatures of up to 180°F. The potential for artesian hot



water wells is also high, especially in eastern Montana. There is need for continued assessment of the geothermal resource throughout the state.

In addition to assessment, there is a need for additional geothermal demonstrations of community space heating and agricultural or industrial applications. These demonstrations should be dispersed as widely as possible across the state; however, recognizing that the geothermal resource must be matched with a local use requirement, the Montana program objective is to select at least one community space heating and one agricultural or industrial use demonstration. In selecting sites, it is important to consider that a geothermal resource can be expanded by the use of direct biomass combustion, and therefore, the proximity of a biomass resource could be considered.

#### Demonstration Technologies

There are few technical unknowns that will require extensive research to support a geothermal demonstration. This does not imply that site specific experiments and tests are not necessary, especially in the area of material and geothermal water compatibility. Drilling and pumping (if necessary) technologies are well in hand as are those necessary for the heat distribution system. Heating and metering units are available for space heating requirements. The specific subsystems that would be required for any agricultural or industrial use may or may not be available; therefore, some R&D may be required.



## Resource Assessment

The location of many hot springs are known in Montana with sufficient water flow and temperature such that they could be used for a low grade heat source. In addition to flow rate and temperature, another important parameter is the dissolved solid elements and amount. The surface conditions do not necessarily represent those present at distances below the surface, specifically the water temperature is considerably higher. This probable temperature increase significantly enhances the energy potential of a geothermal resource.

Three specific examples of hot springs in Montana are at Bozeman, Ennis, and Springdale. The surface output of these springs are:

| <u>Place</u> | <u>Flow Rate</u> | <u>Temperature</u> | <u>Solid ppm</u> |
|--------------|------------------|--------------------|------------------|
| Bozeman      | 30 gpm           | 130°F              | 436              |
| Ennis        | 20 gpm           | 181°F              | 1030             |
| Springdale   | 1315 gpm         | 139°F              | 268              |

For each of these springs, it is expected that there would be significant additional flow at increased temperature from wells drilled in the spring area. The projected available Btu output on a continuous basis for each of these three sites is over  $10^8$  Btu/hr which is equivalent to 700 gallons of gasoline per hour.

In addition to hot springs like these, there are known artesian hot water resources in the Madison formation in eastern Montana. Some gas and oil wells drilled in this region have been hot water producers. Insufficient detail information is known on the underground water resources and temperatures, although projections have been made that indicate a significant resource.



As an element of this program, detail evaluations of known sites and analysis of oil and gas well information across the state will be made. In regions with high potential and high possible use, exploratory wells should be drilled. The overthrust belt and Madison formations should be studied in depth.

#### Demonstration Projects

Once the statewide resource assessment has developed an adequate data base, conceptual studies will be made of at least two sites for a community heating and an agricultural or industrial application. From these studies, one site will be selected for each use. Beginning with the conceptual designs and throughout the project, participation by the community will be encouraged for the central heating concept. For the agricultural or industrial use, a company or individual will probably have to be identified. In both instances, a 10 percent minimum of in-kind or direct financial contribution to the project construction cost is required. As in the biomass projects, system design and costs are refined from step-to-step with the community or individual given the option of proceeding to the next step or dropping the project.

A brief listing of the step-by-step process proposed for geothermal development is given below. The concept and principle of community review, participation, and approval is carried through the program as in the Direct Combustion of Biomass Subprogram. The steps are not listed in the same detail as in the Biomass Subprogram; however, it can be seen that community



and state approval is required before any major commitment is made of the next funding increment.

1. Site resource assessment;
2. Preliminary design and initial capital and operating cost estimate;
3. Community (or company) and state decision to proceed;
4. Resource verification and development, if necessary;
5. Detail design of source, distribution, and end use systems. Updated cost estimates;
6. Firming up of user commitments;
7. Community (or company) decision to proceed;
8. Construction of source, distribution, and end use systems; and
9. Check-out, user hook-up, operation.

#### Additional Issues

Hot springs locations in Montana have been known since the times of the Indians. The better sites have been under private ownership since the nineteenth century. Other sites, still within the public domain, can probably be found; however, the best approach may be to develop those sites already under private ownership.

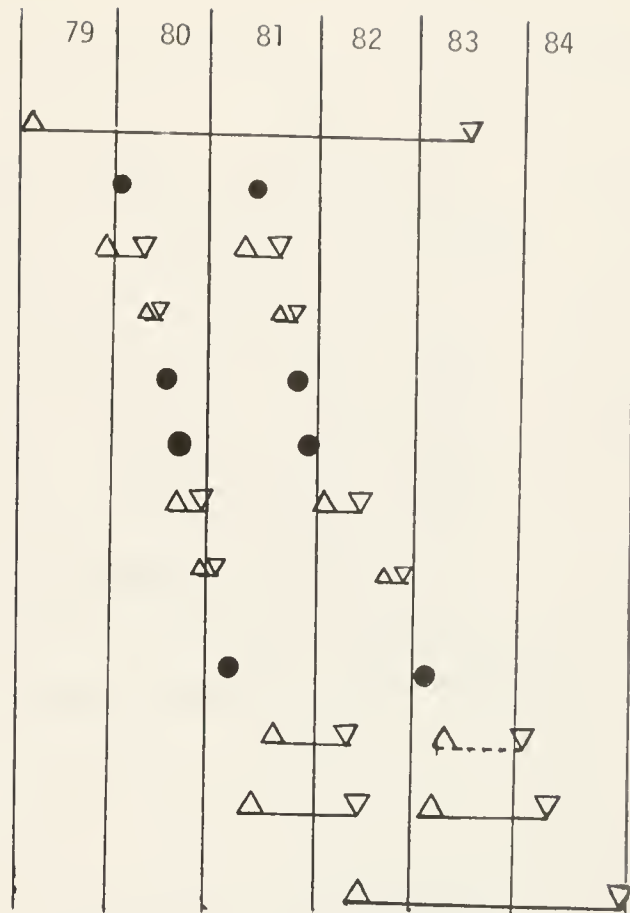
Hot geothermal water is considered a water resource; therefore, water laws must be complied with. This could become a problem with any extensive use regardless of whether or not the water was reinserted into the ground. Other states, e.g. Oregon, consider certain geothermal resources as a mineral resource, making development easier.



## Schedule and Costs

### Program Element Schedule

- . Resources Assessment
- . Study Sites Selection (2 at each time)
- . Conceptual Designs
- . Initial Cost Estimates
- . Selection of Site by State (1 at each time)
- . First Approval by Community/owner
- . Detail Design
- . Final Construction and Operational Cost Estimates
- . Final Approval by Community/Owner
- . "Signing Up" of Customers
- . Construction of Facility and Distribution System
- . Check-out and Operation



### Costs (Dollars in Thousands)

|                                      | 79         | 80         | 81          | 82          | 83          | 84         |
|--------------------------------------|------------|------------|-------------|-------------|-------------|------------|
| . Resource Assessment                | 200        | 310        | 275         | 200         | 100         | 0          |
| . Designs and Community Coordination | 165        | 340        | 360         | 300         | 200         | 0          |
| . Construction                       |            |            | 1000        | 900         | 1600        | 400        |
| . Check Out Initial Operation        |            |            |             | 100         | 100         | 150        |
| <b>TOTAL COST</b>                    | <b>365</b> | <b>650</b> | <b>1635</b> | <b>1500</b> | <b>2000</b> | <b>550</b> |

It is proposed that the yearly costs be shared between the state and federal government at a one-to-five ratio.



## SOLAR SUBPROGRAM

### Introduction

Since 1976, DNRC has supported demonstration projects utilizing solar energy. A review of these projects can be found in the Renewable Alternative Energy Program Report to the 1979 Montana Legislature. In addition, the Montana Energy Office published in May 1978 the Montana Solar Plan. These two documents cover the activities and interest in Montana in solar energy. In this section, a program is proposed that will complete the state support to solar energy use. Because of the past state support, this subprogram differs considerably from those proposed for the other renewable energies in that only a few major tasks remain, and no state funded large demonstrations are required.

### Program Tasks

There are three major tasks remaining to be done in the solar program. The first is a task that is a portion of each subprogram but has not been specifically discussed in the other sections. This is the task of performance monitoring and evaluation of demonstration projects followed by information dissemination to the public. A selection will be made of the most appropriate projects around the state for instrumenting, and these will be monitored during the 1979 to 1980 winter period. The project performances will be analyzed, and the results will be published and made available to the public.

The second task is to promote the development, manufacture, and sale of low cost solar collectors for home size units. Design and material



compatibility with the Montana environment must be established for low cost collectors that can be sold through local builders or hardware stores. A multi-award, competitive, phased contract program for Montana firms is proposed to accomplish this objective. At least two companies will be carried through the full program so that product selection options are assured for the consumer. Both air and liquid systems will be considered with emphasis placed on designs with low cost and mass production capability.

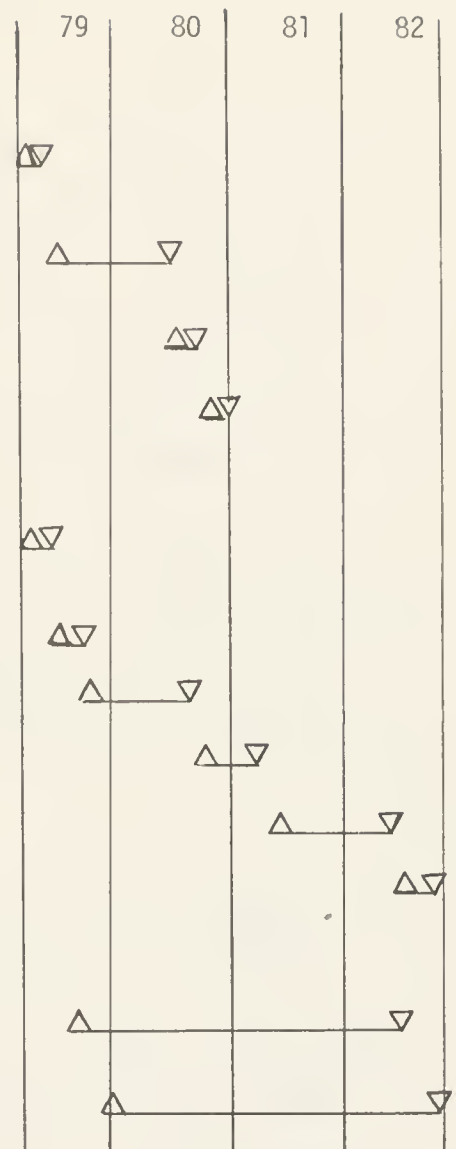
The last task is for the support of designs and cost evaluations of passive and active solar heating systems for private buildings and apartment complexes. No funds will be provided for the construction of demonstration projects; however, support will be given to projects interested in obtaining funding from federal agencies. There are numerous designs and projects across the United States from which valuable information can be obtained. This task will provide funds for Montana architects and consulting engineers to design and make cost estimates on solar-using facilities. The concept is to provide funds for the increase in design cost associated when solar use is considered. The present or new building owner is expected to pay all design costs associated with conventional facility design. The building owner pays all construction costs. This program provides the additional funds necessary to assess a solar option for a facility and, in addition, enhances the design skills of Montana architects and consultants in using solar energy for other customers.



## Schedule and Costs

### Program Element and Schedule

1. Solar demonstration evaluation
  - . Selection of solar demonstration sites for performance monitoring
  - . Instrumentation installation and measurement
  - . Site performance evaluation and analysis
  - . Publication of results
2. Solar Panel Development
  - . Development of solar panel characteristics objectives for Montana
  - . Multi-award phase one development
  - . Panel evaluation and selection for follow-on
  - . Multi-award phase two development
  - . Panel evaluation and analysis
  - . Publication of results
3. Solar "Building" use design assistance
  - . Continuing evaluation of design assistance requests
  - . Design assistance grants on selected projects



| Costs (Dollars in Thousands)              | 79  | 80  | 81  | 82  |
|---|-----|-----|-----|-----|
| 1. Solar demonstration evaluation         | 40  | 50  | 60  | 50  |
| 2. Solar panel development                | 125 | 165 | 110 | 70  |
| 3. Solar "Business" use design assistance | 50  | 65  | 100 | 85  |
| TOTAL COST                                | 215 | 280 | 270 | 205 |

Program ends in 1982.



## SMALL SCALE HYDROELECTRIC SUBPROGRAM

### Introduction

The use of water to generate electricity in Montana is widespread, and all of the possible large scale generation sites have plants or have been studied. There are many smaller dams used for irrigation or flood control which do not have generators. There exists adequate technical capability within the state to perform the required design and cost estimates to determine whether or not these sites could generate electricity economically. This program will not support this type study, but rather, it has as its objective the support of hydroelectric generators on small streams of a few kilowatt capacity for individual land owner use. The key criteria are that the maximum generating capacity is limited to 20 KW and that the electricity is for on-site consumption.

### Program Tasks

This program differs in that no state funds will be used for energy resource assessment. The first task will be the preparation of an information and "how to" report for individuals interested in assessing their own small scale "hydro" resource. This report will be made available to individuals in the state at their request. After reading the report and assessing their own resources, individuals may desire to make application to the state for assistance in establishing a small scale hydroelectric system. Program assistance is limited initially to design and total system cost estimates. After which, the state and individual must mutually agree that the construction of the proposed system would be beneficial to the state (from a demonstration



point of view) and to the individual. If the proposed system is not selected for additional funding support, the individual may use the information generated and proceed at his own expense. For those sites on which both the state and individuals agree, the program will provide construction funding support of up to 90 percent of the cost. The individual is expected to provide the additional construction costs and all costs for operation and maintenance. The state will provide limited direct on-site technical assistance if requested by the individual during the check-out and first few weeks of operation.

The individual will be expected to maintain a record of the system performance for one year after check-out. Bimonthly informal reports will be written by the individual for which he will receive \$150 per acceptable report. Any cost for special instrumentation required to monitor the system performance will be paid in full by the program.

The individual is expected to pursue all questions and legal expenses associated with water use and rights. The water rights situation at the proposed site must be explained in the initial request to the state for assistance. The water rights issue must be cleared up completely at the individual's own expense prior to any decision by the state to assist in system construction.

It is expected that request for consideration will be received from 50 to 60 sites, that 20 will be selected for design assistance, and that ten will be selected for construction assistance.



There exist commercial small scale hydro systems; therefore, only limited component development support will be required for Montana or site specific technical problems. Funds are provided to solve these problems as they develop.

#### Schedule and Costs

|  | 79  | 80 | 81 | 82 | 83 | 84 |
|--|-----|----|----|----|----|----|
| . Small Scale Hydro Information Preparation                | △ ▽ |    |    |    |    |    |
| . Design Assistance to Interested Individuals              |     | △  |    |    | ▽  |    |
| . Construction and Check Out Assistance for Selected Sites |     |    | △  |    |    | ▽  |
| . Performance Evaluation and Monitoring                    |     |    | △  |    |    | ▽  |
| . Required Development Support of Components               |     | △  |    |    | ▽  |    |

#### Cost (Dollars in Thousands)

|  | 79 | 80  | 81  | 82  | 83  | 84 |
|--|----|-----|-----|-----|-----|----|
| . Information Packet Preparation                               | 40 | 0   |     |     |     |    |
| . Request Evaluation and Design Assistance                     | 0  | 50  | 60  | 85  | 40  |    |
| . Construction and Check Out Assistance                        | 0  | 0   | 85  | 110 | 140 | 40 |
| . Montana and Site Specific Development Support for Components | 0  | 50  | 100 | 75  | 50  |    |
| TOTAL COST   | 40 | 100 | 245 | 270 | 230 | 40 |



# DEPARTMENT OF RESOURCES AND CONSERVATION

## SUPPORTING PROGRAMS

In support of the technology subprograms outlined in the proposed renewable energy program, the DNRC will have activity in the following four areas: Human Services, Incentives, Standards and Practices, and Program Management. The specific activities to be performed under each of these areas are described in detail in the DNRC January 4, 1979 Montana Alternative Renewable Energy Sources Program. What is included here is the recommended funding level for these areas required to support the expanded technology program proposed in this plan.

| DNRC Program Area                    | 79  | 80  | 81  | 82   | 83   | 84   |
|--------------------------------------|-----|-----|-----|------|------|------|
| Human Services                       | 85  | 105 | 210 | 220  | 250  | 210  |
| Incentives                           | 20  | 35  | 100 | 135  | 75   | 50   |
| Standards and Practices              | 110 | 160 | 300 | 315  | 490  | 305  |
| Program Management                   | 140 | 210 | 345 | 405  | 460  | 490  |
| <hr/>                                |     |     |     |      |      |      |
| TOTAL COST<br>(Dollars in Thousands) | 355 | 510 | 955 | 1075 | 1275 | 1055 |

This budget is not a percentage of the total program dollars but is determined from an estimate of the work required under each area. In addition to the management budget shown above, there are funds for management included in the budgets under each subprogram by the major subcontractor selected.



# BUDGET SUMMARY

These figures are compiled from each of the subprograms described in the plan. (Dollars in Thousands)

|   | <u>79</u> | <u>80</u> | <u>81</u> | <u>82</u> | <u>83</u> | <u>84</u> | <u>Total</u> |
|---|-----------|-----------|-----------|-----------|-----------|-----------|--------------|
| Subprograms   |           |           |           |           |           |           |              |
| . Biomass   | (2000)    | (3155)    | (3745)    | (4750)    | (6095)    | (7800)    | (27545)      |
| Alcohol   | 1150      | 1500      | 1100      | 1400      | 1800      | 1800      | 8750         |
| Direct Combustion   | 650       | 1355      | 2195      | 2450      | 3610      | 5400      | 15660        |
| Biogas  | 200       | 300       | 450       | 900       | 685       | 600       | 3135         |
| . Wind  | 625       | 800       | 1050      | 1200      | 1200      | 555       | 5430         |
| . Geothermal  | 365       | 650       | 1635      | 1500      | 2000      | 550       | 6700         |
| . Solar   | 215       | 285       | 270       | 205       | 0         | 0         | 975          |
| . Small Scale Hydroelectric                                       | 40        | 100       | 245       | 270       | 230       | 40        | 925          |
| . DNRC: Human Services<br>Incentives, Standards<br>and Management | 355       | 510       | 955       | 1075      | 1275      | 1055      | 5225         |
| TOTAL COST  | 3600      | 5500      | 7900      | 9000      | 10800     | 10000     | 46800        |
| Proposed State Share  | 900       | 1100      | 1300      | 1500      | 1800      | 2000      | 8600         |
| Proposed Federal Share  | 2700      | 4400      | 6500      | 7500      | 9000      | 8000      | 38200        |
| Cost Sharing Ratio  | 3:1       | 4:1       | 5:1       | 5:1       | 5:1       | 4:1       | 4.43:1       |

The budgets are expressed in terms of 1979 dollars, and no adjustment has been made for inflation. The federal contribution increases in the first years as the program effectiveness is demonstrated. The federal contribution is reduced in the last year because the funds required to complete the program do not require a 5:1 federal match with the projected coal tax revenue.

The program assumes a February 1979 start but can be operated with a six month slip if the state funds become available in June and the federal funds become available in October of each year.





